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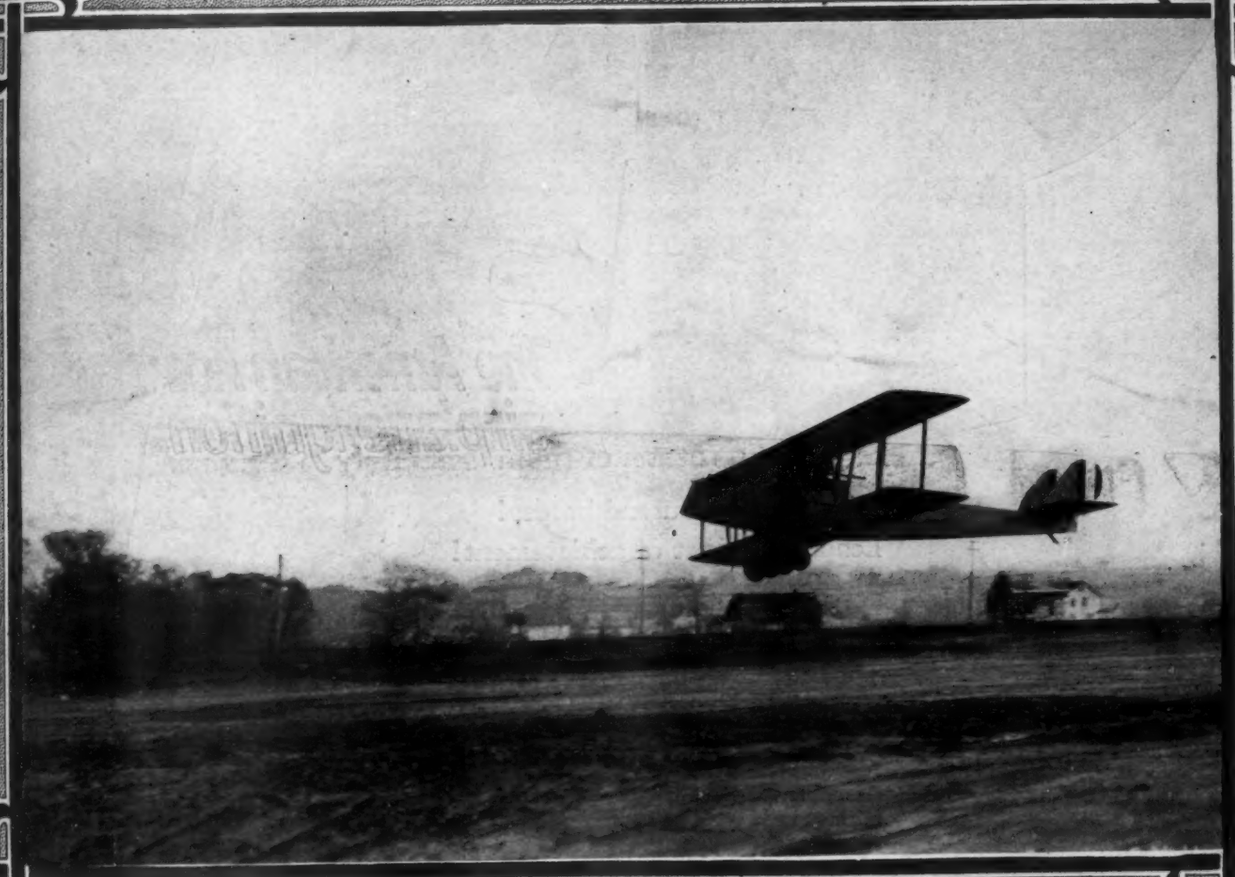

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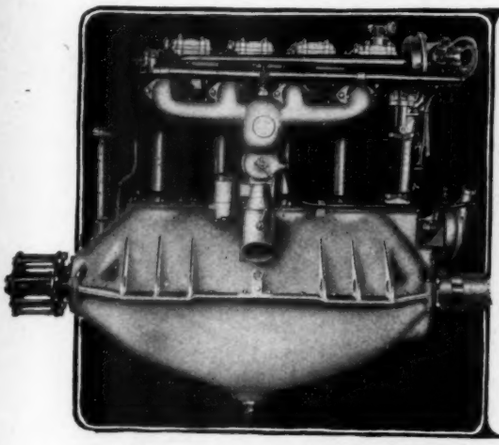

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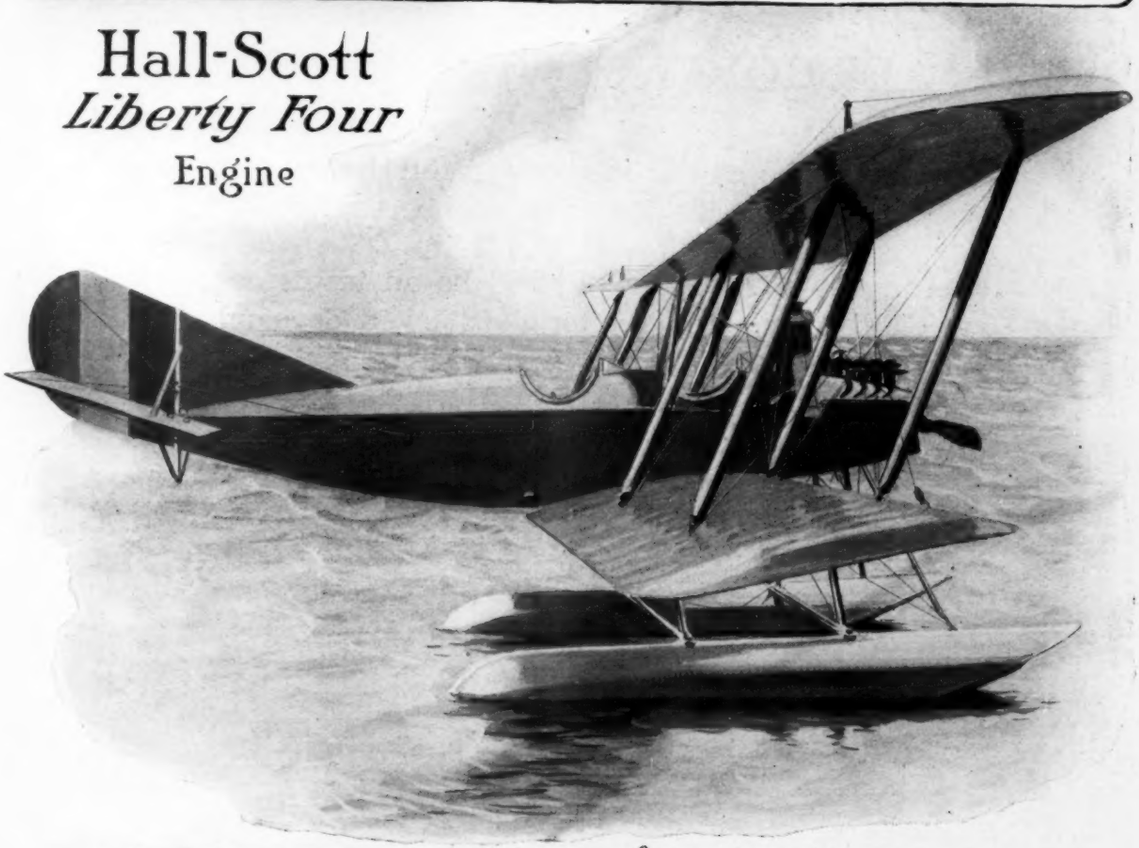

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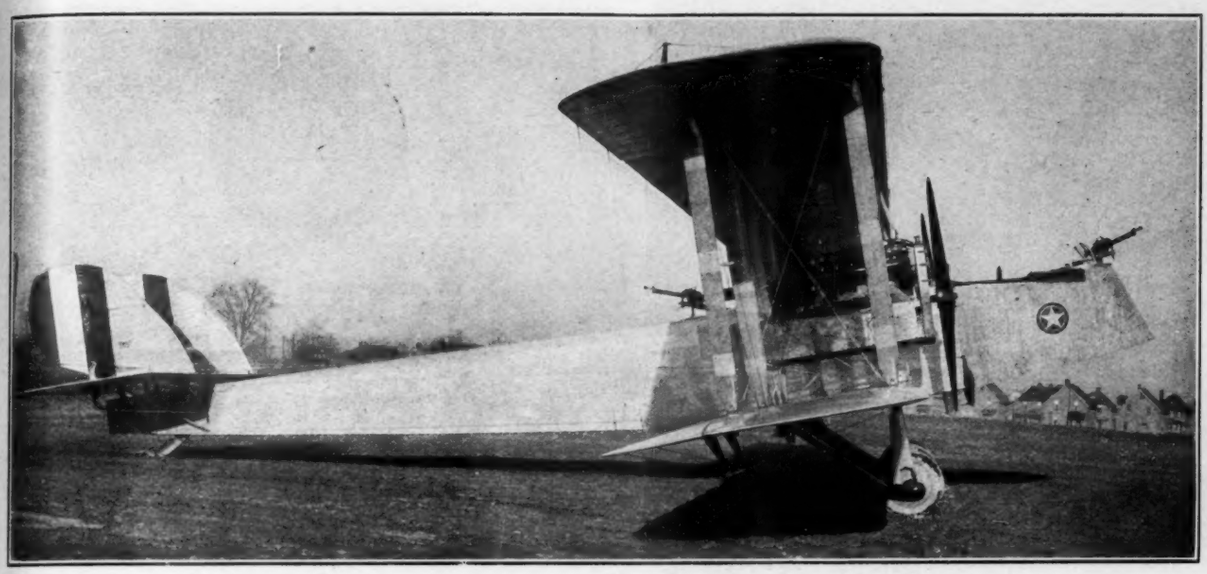

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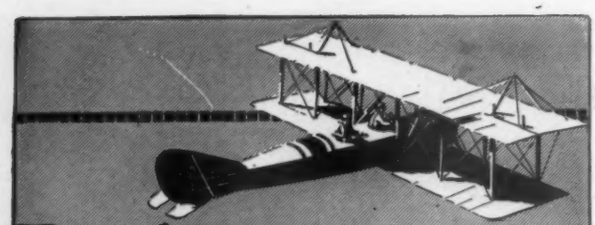

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FEBRUARY 15, 1919

AVIATION
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VOL. VI. NO. 2

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What the coming year has in store for American Industry is the question in the mind of every business man. The answer depends entirely upon ourselves.

A forward look and immediate action are necessary. The man that fears radical readjustments and declining prices and selfishly waits to get the full benefit of these will be left behind in the commercial race. If all should do this, it would mean disaster. Fair wages and fair prices mean prosperity. There is an ample market for all our products at their present values. We must translate our belief in the future into purchasing and production if we are to be ready for the rising tide of business.

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Vol. VI | February 15, 1919 | No. 2

THE lack of emphasis that is placed on the need for officers trained in aeronautical engineering for the Air Service in all plans outlined for the future, should be corrected, for the greatest need that this country will have in its aerial development and the hardest one to supply is for trained engineers in the army.

It used to be customary that the highest ranking cadets at the Military Academy at West Point were assigned to the Engineer Corps and the achievements of this branch of the army have reflected the policy. As no branch of engineering requires a sounder knowledge of a technical nature than aeronautics, some provision should be made for the training of officers in air science.

The Navy has always excelled in engineering owing to close contact with all its problems. It may be that the results which the naval aeronautical program secured during the war is due to the training of the officers in aeronautics.

In view of the perfunctory instruction which is given military aviators in matters technical, it would be an unfortunate policy to put these officers in engineering positions of authority, even for general maintenance work. During the war the Air Service has been able to draw, for its technical personnel requirements, upon a vast reservoir of reserve officers who were sufficiently trained for this emergency by virtue of their pre-war profession. However, for the future comprehensive plans should be developed for imparting sound technical training to engineer officers of the Air Service, because the work of creating such a corps by improvisation will grow more and more difficult as the scope and technique of military aeronautics expand.

For accomplishing this result two courses are open. The first consists in providing within the Air Service Academy the War Department proposes to establish, for an aeronautical engineering department, to which the most promising officers would be detailed. The alternative, for which method the Navy furnishes a successful precedent, would consist in sending officers for specialized training to engineering schools. The latter has been the less expensive method of the two, and has, furthermore, given most excellent results, for the Navy has thus been able to secure for its specially detailed officers a broader training than could be given by a limited course.

The Radial Fixed Cylinder Engine

In a recent paper read before the S. A. E. very interesting study is made of the radial fixed cylinder engine, of the air cooled type. Very soundly the author concludes that the revolving air cooled engine has reached the limit of its development, and that the rotating water cooled engine has too many inherent disadvantages to be seriously considered.

We differ from the statement that the V-type water cooled engine has been fully developed. It is true that for war purposes the 400-hp. Liberty is an almost perfect example of this type. But the 400-hp. is not the limiting size of the V-type engine. For military purposes the large day or night bomber still remains to be equipped with two 800-hp. V-type engines; for the large commercial passenger or freight carrier, for the transatlantic airplane, development along the same lines is required. The present size V-type aeronautical engine also requires considerably more study, if it is to be really adaptable to commercial use. The war has pushed its development to an extreme of lightness. Now its weight must increase—as little as possible of course—to give greater reliability and smoothness of operation, less rapid deterioration and less repair work. The work on this type is by no means exhausted.

Still thinking in the war way, however, the radial engine does certainly seem to offer possibilities. Comparing weight of power plant, very interesting figures are given. For a new design or a 200-hp., ten-cylinder radial air-cooled engine of 4 17/32 in. bore and 6¼ in. stroke a weight of less than 1.8 b. per hp. installed is claimed. The Liberty motor complete with cooling system certainly is in the neighborhood of 2.5 lb. per hp. Official British reports give a fuel consumption of less than 0.5 lb. per b. hp. hr. with a fuel consumption of less than 0.02 lb. per b. hp. hr. This compares very well with the consumption of any water-cooled motor.

The cooling of a water-cooled V-type motor is a difficult problem in design, but not an insoluble one, and by the use of shutters, or other simple mechanical devices, it can be made to adjust itself to any altitude. In the fixed radial there is still the difficulty that we are not able, as yet, to vary at will the cooling of the engine, and this may be a serious drawback.

It will certainly be quite as accessible, if not more so, with the V-type. Whether in large sizes it will lend itself to streamline effects of the body is doubtful, since the maximum diameter of the engine is likely to be very large. It will certainly be more easily detachable. The actual mounting of a radial engine will present somewhat greater difficulties, with its overhanging cantilever action, than the V-type, which can be made to sit so snugly on veneer engine mounting.

On the whole, the development of this type of engine should be strongly encouraged and airplane constructors will no doubt watch this with considerable interest.

The 80 Hp. Le Rhone Airplane Engine

The 80 hp. Le Rhone revolving cylinder engine is one of the few pre-war types existent today. It has been used extensively at the front for scout and combat duty, but of late principally in observation and bombing, notably in the twin engined Caudron biplane. In this country it has been used in fast solo scouts for advanced training in aerobatics and combat flying, the Thomas Morse S-4-E, the Standard ME1 Scout and other similar planes being used.

The Union Switch & Signal Co., a Westinghouse concern with plant at Swissvale, Pa., in the Pittsburgh District, were called upon to manufacture the Le Rhone 80 hp. engine in October, 1917, and the drawings were furnished them at that time. Machinery was immediately installed in a new modern factory building and production engines were accepted by the Government the following April.

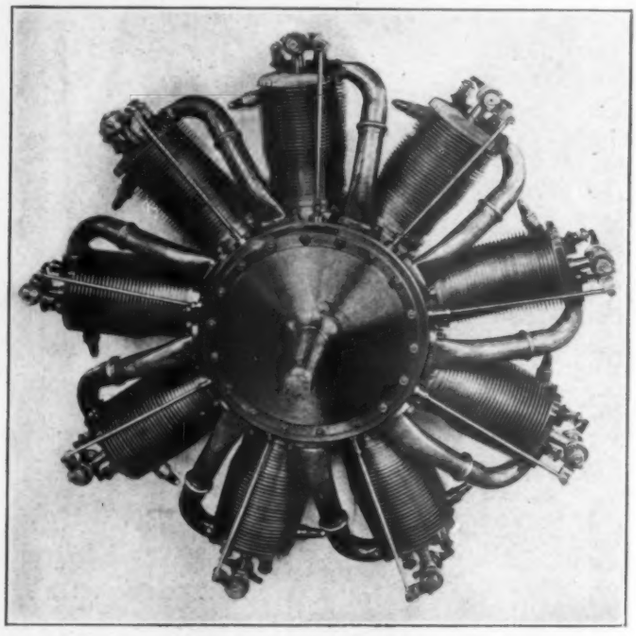


FIG. 1. FRONT VIEW OF THE 80 HP. LE RHONE ENGINE

The engine produced is a copy of the French engine with changes in some minor details and with materials selected from American sources. The materials have been superior to those of the French, which, together with special treatment, has resulted in practically eliminating engine failures from defective materials. The engine is almost entirely constructed of steel, the only castings being pistons, connecting rod bushings, thrust block liners and a few accessory parts; there are 32 forgings. The initial weight before machining is 1160 lb., the finished weight is 184 lb.

Advantages of the Rotary Engine

1. The elimination of cooling water, radiator and piping by revolving the self-cooling cylinder in the air at high speed.

2. The arrangement of a number of cylinders on a short crankcase with only one crank pin gives a light weight, compact unit.

3. Regular rotation and an absence of vibration is produced by the flywheel effect of the cylinders and crankcase revolving at high speed.

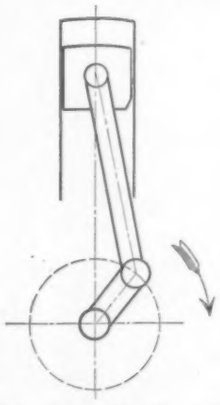


FIG. 3. FIXED CYLINDER ENGINE

4. Owing to the absence of water cooling, the erection and dismantling of the engine on the plane can be carried out with complete safety and in minimum time; likewise simplicity in the design of the engine makes for ease in its disassembly.

5. From a military standpoint, the air cooled revolving cylinder engine is much less susceptible to injury and makes an effective shield for the pilot against head on machine gun fire.

The Principles of the Rotary Engine

The Le Rhone is a simple four cycle engine in which the functions of inlet, compression and exhaust take place in the same manner as in a four cycle engine of the fixed cylinder type. When the engine is fixed (Fig. 3) the force of the explosion moves the crankshaft but when the crankshaft is fixed (Fig. 2) the force of the explosion moves the cylinder in the opposite direction.

The crank OT being fixed, the cylinder C is free to turn around the engine center O. The piston A turns about the center T with the connecting rod TA as radius. Due to the eccentricity of these axes of revolution, one rotation of the cylinder will produce a complete stroke of the piston, since the distance between the piston and the top of the cylinder and likewise the length of the line OA, varies with the position of the radius TA. The distance is a maximum when the cylinder is vertically below O and a minimum when it is vertically above T. The difference between these distances is equal to the stroke of the engine or twice the length of the crank OT.

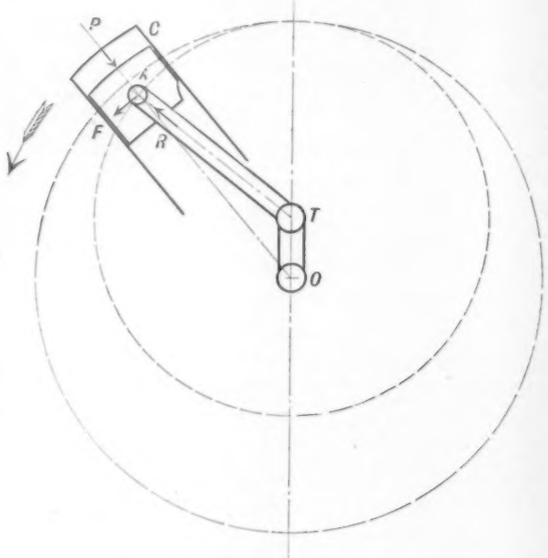


FIG. 2. REVOLVING CYLINDER ENGINE

When the explosion occurs the force P is resolved into a force R in the direction of the connecting rod TA and a force T at right angles to the center line OA of the cylinder and piston. The force R is destroyed by reaction since the point T is fixed and the force F tends to turn the cylinder around the center O in the direction of the arrow.

In order to balance the rotating masses and eliminate dead centers, there are arranged around the crankcase a number of cylinders on the one crankshaft.

To produce an even torque, the cylinders must fire alternatively, for if they fired consecutively, all would fire in one revolution and none in the next. An odd number of cylinders must be used to provide equal intervals between the explosions.

The firing order for nine cylinders is 1, 3, 5, 7, 9, 2, 4, 6, 8. If an even number of cylinders were to be used, such as eight, the firing order would be 1, 3, 5, 7, 2, 4, 6, 8 but the interval between the firing of the cylinders 7 and 2 would not equal that of the other cylinders, as can be demonstrated graphically by making a layout of the eight cylinder positions.

Features of Design

The engine consists of two elements, the fixed part and the rotating part.

The fixed part consists of a hollow crankshaft, two engine supporting plates and the carburetor. The carburetor is mounted on the extreme end of the crankshaft and supplies the vaporized mixture through the hollow shaft to the crankcase. On the main supporting plate, which is keyed to the crankshaft, are mounted the magneto, the distributor brush and the oil pump. The short end crank, formed by the extension of the shaft at the propeller end, is located on the crank pin by a taper and round key and is held by a locknut.

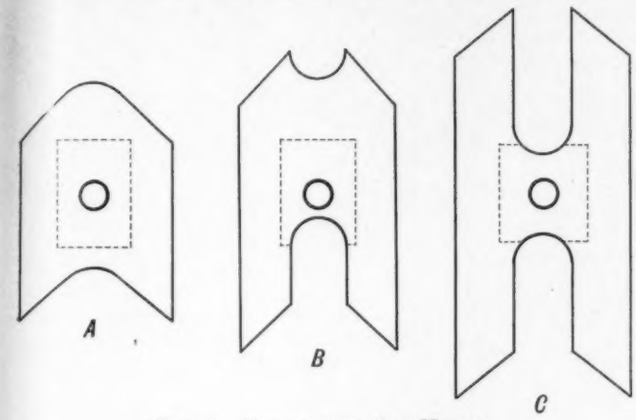


FIG. 4. CONNECTING ROD HEELS

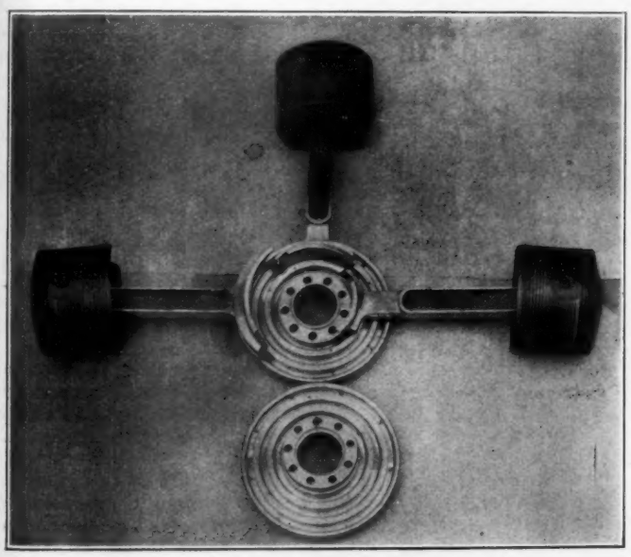


FIG. 5. THRUST BLOCK WITH ONE-TYPE CONNECTING RODS AND PISTONS

The crank shaft is machined from high grade chorme-nickel steel forging oil tempered to give high elastic limit and weighs 59.5 lb. before and 11.15 lb. after machining.

The rotating part consists of crankcase, cylinders, intake headers, pistons with connecting rods and thrust block, valve gear and ignition distributor.

Ball bearings are used exclusively for rotating elements. There are nine sets of ball bearings on the crankshaft. All the ball bearings within the crankcase and housings are of the retainer type.

The crankcase is in the form of a steel cylinder provided with nine bosses having threaded openings into which the cylinders are screwed. It is a 40 to 50 per cent carbon open hearth steel forging, specially heat treated and weighing 274 lb. before, and 28¼ lb. after machining. The propeller shaft is made integral with the front crankcase cover and is machined from a chrome-nickel steel forging, oil tempered. The thrust bearing housing is bolted on the rear of the crankcase, and on it are mounted the magneto and oil pump drive gear and the ignition distributor ring. The crankcase parts revolve about the shaft on three sets of ball bearings, the propeller thrust is absorbed by a double row ball thrust bearing.

The cylinder is a 40 to 50 per cent carbon open hearth steel forging weighing 62½ lb. before and 7¾ lb. after machining, specially heat treated after rough turning and has cooling fins turned on the outside barrel and on the head. It is provided with a cast iron liner pressed into place.

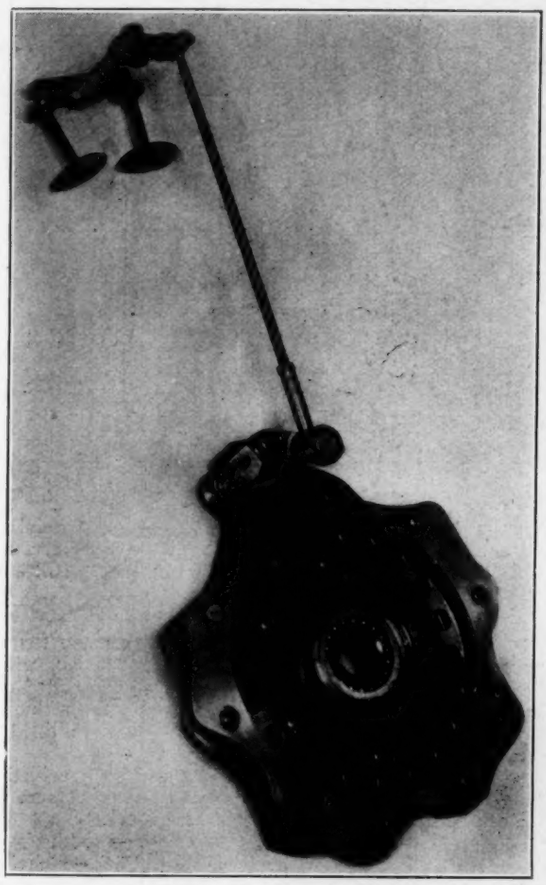


FIG. 6. VALVE GEAR

The cylinder, held in the crankcase by threads cut at its base, is prevented from further rotation about its own axis by a locknut which screws down against the crankcase boss. In each engine assembly, in order to prevent vibration, such cylinders are selected as have equal weights. They must have not only equal total or static weight, but they must also have the same dynamic weight or moment about the center of engine rotation.

The two valves, with seats provided in the steel cylinder head, are actuated by an oscillating rocker arm and a single push rod, the rocker arm being supported on two ball bearings. The valves are made of chrome-nickel steel, and are provided with a screw driver slot for grinding in the 36½ deg. seat. The guide is a cast iron bushing pushed into a steel retaining sleeve which is screwed into the valve cage and held by a locknut.

The valve spring is of steel wire single coil, of 3½ lb. tension with the valve in a closed position. No spring is required except at starting; at a speed of 1,200 r. p. m. the centrifugal force acting on the valve is about 85 lb.

The copper intake headers which convey the carbureted mixture from the crankcase to the inlet valve cages are made in two pieces with a slip joint sealed by a rubber ring.

Pistons

The piston, a special semi-steel casting, is 0.1654 in. thick at the head and weighs 1.6 lb. The maximum allowance for pis-

ton weights in one engine is 0.03 lb. The skirt is very thin below the piston pin and is machined on the outside with a coarse ⅛ in. turning feed, which provides an oil carrying surface with minimum bearing and friction surface. The skirt is straight with the exception of a slight taper at the ring grooves and has ten oil holes.

The piston pin, of case hardened nickel steel specially treated, has tapered ends and is driven into the piston pin bosses, where it is held by a through bolt. The diameter of the pin is 0.63 in.

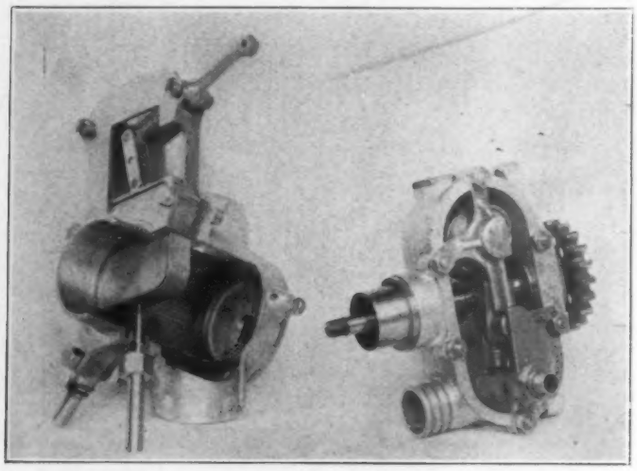


FIG. 7. SECTIONAL VIEWS OF CARBURETER AND OIL PUMP

The steel piston rings, snap form, are given special treatment and are very effective. They require very careful manufacture and are lapped in the cylinder to insure a full bearing on the cylinder wall.

Connecting Rods

The H section connecting rods are connected to the crank pin by means of the connecting rod thrust block, which is made in two halves and runs on ball bearings mounted on the crank pin. The halves of the connecting rod thrust block are provided with three annular concentric grooves lined with bronze.

The lower ends of the connecting rods are provided with "heels" which fit into the thrust block groove, there being three connecting rods contained in each groove.

There are, therefore, three sets of connecting rod heels which vary in size and form in order to conform to the diameters of their grooves and to allow the heels freedom of movement in sliding under each other. Connecting rod Nos. 1, 4 and 7 have short heels, Nos. 3, 6 and 9 have medium length, and Nos. 2, 5 and 8 have long heels.

The heels have but slight motion relative to the thrust block, since the thrust block and rods revolve on ball bearings; the slight movement that does occur comes from the change in angularity of the adjoining rods. The clearance of the heels in the thrust block is 0.005 in. Nine screws hold the thrust block halves together and are locked by peening into the screw driver slot. The thrust block is held on the crank pin by the short end crank.

Fig. 4 shows the three types of connecting rod heels. Fig. 4 shows the thrust block halves with one of each type connecting rod and three pistons.

Valve Gear

The valve actuating mechanism consists of two cams, one inlet cam and one exhaust cam, operating nine cam rockers each connected to its valve push rod. The cam rockers receive an oscillating motion caused by contact of the inlet cam rollers and the exhaust cam rollers on their respective cams.

In considering the timing and cam action of the engine, it is necessary to bear in mind that centrifugal force on the push rod pulls the rod outwards and keeps in inlet roller in hard contact with the cam (Fig. 6). This contact is maintained with the engine up to speed, except at opening of the exhaust valve when an additional positive push by the exhaust cam is required to open the valve against the pressure which then exists in the cylinder.

The two cams are bolted on to either side of the cam hub, which is free to rotate on the ball bearings mounted on the short end of the crankshaft. A plate which is mounted on ball bearings at the extreme end of the crankshaft has a gear wheel of 45 teeth bolted on it. This gear is concentric with the crankshatt and is in mesh with an integral gear of 50 teeth bolted on the cam hub. To allow the gears to mesh, the cam hub and ball bearings are mounted eccentrically to the crank-

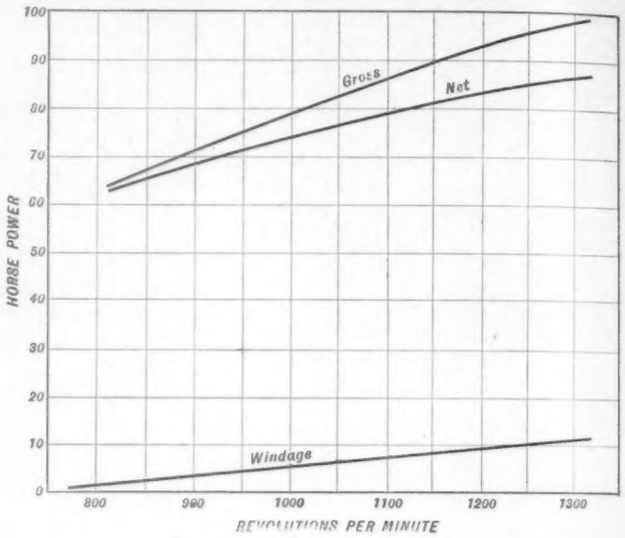


FIG. 8. PERFORMANCE GRAPH

shaft, the amount of eccentricity corresponding to the difference in radius of the two gears.

The cam, though revolving with the engine, is lagging at the rate of 45 to 50, or one tenth, so that in the two revolutions necessary for a four cycle engine one fifth of the entire cam will have passed under the cam rocker.

The profile of each cam is repeated exactly five times around the circumference. This profile, combined with the eccentricity and the centrifugal force of the push rod, gives the nine valve rockers the necessary motion to open and close the valves.

Ignition

The magneto is mounted on the main supporting plate and has a pinion of 16 teeth, which engages with a gear of 36 teeth on the rotating thrust bearing housing. A high tension cable conducts the current to a brush holder which is also fixed on the main supporting plate; the carbon brush bears on a distributor ring mounted on the thrust bearing housing. The fibre distributor ring has nine separate brass inserts or segments with external terminals for attaching the copper wire for the spark plugs. The ignition cannot be advanced or retarded at will, as the distributor brush is fixed on the main supporting plate. The distributor transmits the current to the alternate cylinders in the order 1, 3, 5, 7, 9, 2, 4, 6 and 8, the point of ignition for each cylinder corresponding to the moment when the platinum contacts of the magneto separate.

Lubrication

The oil pump is bolted to the main supporting plate; its gear engages with the gear on the thrust bearing housing. The oil pump shaft drives a worm wheel on which is mounted the oil pump crank. A plunger driven by the crank moves up and down in the cylinder, which is caused to oscillate about its pivot by the plunger and crank. An adjustable spring keeps the oscillating cylinder against the oil pump cover which contains the pressure outlet. The cylinder port registers on the suction stroke with a channel conducting oil from the oil pump body, and on the delivery stroke with the pressure outlet. A pulsation glass mounted on the instrument board shows that the pump is working, and as the oil pump crank ratio is 27.78 to engine speed, the pulsations can be used for determining the r. p. m. of the engine.

The oil is conducted by a pipe to a union on the top of the main supporting plate, it penetrates the crankshaft and flows through a channel arranged in the aluminum oiling sleeve from which it passes into oil holes in the crank web, crank pin, short end crank. A small hole in the aluminum oiling sleeve beneath

the thrust bearing supplies the thrust bearing, the rear ball bearing and the main crank case ball bearing. A tube conducts oil from the crank web to the interior of the cylinders. A drilled hole in the crank pin provides oil for the connecting rod thrust block, its ball bearings and the connecting rod heels. Oil which passes through the hole in the connecting rod heel is impelled by centrifugal force to the piston pins.

Drilled holes in the short end crankshaft supply the false nose plate bearing and the cam bearings, holes in the cam hub conduct the oil by centrifugal force to the cams and cam rockers.

The cylinders and pistons are supplied by spray, surplus oil being carried away with the mixture. Castor oil and heavy mineral oil of high viscosity are used.

Carburetion

The carburetor, which is fastened at the end of the hollow crankshaft, consists of a tube with a sliding shutter and a spray nozzle. The opening in the spray nozzle is controlled by a long tapered needle which is lifted out of the jet opening when the air shutter is raised. The amount of fuel supplied to the carburetor is controlled by the gasoline regulator, which is merely a needle valve fitting and a filter screen.

Specifications

80 HP. LE RHONE ENGINE

Type of engine	Radial revolving, four stroke
Rated horsepower	80
Normal speed	1200 r.p.m.
Number of cylinders	9
Cylinder bore	105 mm. (4.1369 in.)
Stroke	140 mm. (5.5120 in.)
Piston displacement	667 cu. in.
Compression ratio	4.8 (70½ lb. absolute)
Order of firing	1-3-5-7-9-2-4-6-8
Method of cooling	Air
Diameter of inlet and exhaust valves	1.8 in.
Diameter of valve stems	0.315 in.
Lift of inlet and exhaust valves	18/32 in.
Carburetor (mixing valve with gate throttle and metering pin)	Block tube type
Magneto	Fixed spark
Direction of rotation	Clockwise
Speed	2¼ times engine
Make	Splitdorf-Dixie
Breaker gap	0.020 in.
Spark plugs	Splitdorf (Le Rhone Special)
Gap	0.020 to 0.024 in.
Oil pump	One plunger, oscillating cylinder
Director of engine rotation	Normal (counter clockwise from propeller end)
Fuel consumption	.8 to 10 gal. per hr. or 0.6 to 11.5 lb. per b. h. p. hr.
Fuel recommended	60° to 72° Baumé (0.740 to 0.690 sp. grav.)
Oil consumption	1 1/3 gal. per hr. or 0.12 lb. per b. h. p. hr.
Oils used	Castor oil, or heavy mineral oil of high viscosity
Engine weight, complete with accessories	260 lb.

Navy Issues Seaplane Specifications

The Bureau of Supplies and Accounts of the Navy Department has issued a schedule for furnishing plans, supervisory assistance and construction of seaplanes, bids on which will be opened on 10 a. m., March 25, 1919. This schedule asks for (1) proposals for furnishing plans and such detailed data as will enable a producing aircraft concern to construct two experimental machines, including a proposal for rights of the Navy Department to manufacture other seaplanes of the type, and to incorporate any features in other seaplanes; (2) proposals for furnishing expert supervisory assistance in the construction and demonstration of the aforenamed two experimental machines in accordance with plans submitted by the bidders under item (1); and (3) proposals for the construction of three machines in accordance with items (1) and (2) and demonstration of one of them as herein provided, making the guarantees called for in this proposal.

The department reserves the right to make award on any part or all of the items above, or to accept or reject any bids. It is the intent of this schedule to secure proposals for the designs for and the construction of seaplanes capable of operating from shipboard, complying so far as possible with all the requirements herein described; and to be built in accordance with General Specifications for Airplanes No. 100, except as modified by this schedule.

The following particulars should be forwarded with the proposals in order to secure consideration by the department:

General arrangement sketches or plans showing plan side and front elevations. These sketches should show the following:

(*a*) Over-all dimensions.

(*b*) Over-all dimensions of parts or packages when ready for stowage aboard ship.

(*c*) Gap, chord, and stagger.

(*d*) Positions and angles relative to the propeller axis for the main and auxiliary surfaces and floats.

(*e*) Position of center of gravity of airplane for full load and light load as defined under "Rules Governing Conduct of Trials." See General Specifications for Airplanes No. 100.

(*f*) Position of center of buoyancy and corresponding water line of the float system when at rest on the water with full load.

(*g*) Position of axis of launching wheels (if any) relative to center of gravity for full load.

(*h*) Clearance of the propeller: A—For tractor types to be shown with the propeller axis horizontal. B—For pusher types to be shown with the airplane in position at rest on the surface.

(*i*) Angle of attack at rest on the surface under full load.

(*j*) Areas of main and auxiliary surfaces.

(*k*) Dihedral angle; sweep back; washout or permanent warp, if any.

Detail sketches of plans as follows:

(*l*) Sketch of float construction and a statement of reserve buoyancy.

(*m*) Sketch of aerofoil, showing with dimensions the positions of the spars and details of wing ribs.

(*n*) Sketch showing sizes and types of spars, interplane struts, strut fittings, and wing hinges.

(*o*) Sketch showing launching gear, size of wheels, tires, axles, etc.

(*p*) Sketch showing weight of launching gear.

(*q*) Detailed tabulation of estimated weights, showing weights included in light load and full load, with the calculation of the location of the center of gravity vertically and horizontally for each of these conditions with reference to the front edge of the lower plane with the propeller axis horizontal. For this purpose reference is made to definitions of "light load," "full load," and "useful load," in "Rules Governing Conduct of Trials." (Specification No. 100.)

(*r*) Diagram showing loads on the principal members of the wing and body truss, to include a tabulation of the characteristics of the principal members, their loads and stresses under the several conditions specified under "Factors of Safety." (Specification No. 100.)

(*s*) Calculated performance chart, showing the curve of effective horsepower required, the propeller efficiency, and the effective horsepower available, all based on velocity of advance in knots; also a curve for the engine employed, showing brake horsepower plotted against revolutons per minute.

(*t*) A statement of the type and principal characteristics of the engine proposed, together with oil and fuel consumption per brake horsepower hour at normal brake horsepower.

(*u*) A statement of the estimated performance with full load at sea level, to include the following items: (*a*) Weight, full load; (*b*) useful load; (*c*) maximum speed; minimum flying speed; (*d*) load in pounds per square foot of plane area, including ailerons; (*e*) load in pounds per horsepower; (*f*) tank capacities for fuel and oil; (*g*) endurance at full power at sea level.

(*v*) A quotation of price and place and time of delivery.

Functions

The functions of the new type which it is desired to develop are considered to be as follows:

(*a*) *To be launched from the bow of a ship steaming into the wind.*—Designers may assume for this requirement that the seaplane will run off under its own power, using skids or a wheeled carriage with a run of about 75 feet against a relative wind of 25 knots made up of 10-knot head wind and 15-knot speed of vessel. It follows that the load per brake horsepower for the seaplane must be low enough to provide for quick acceleration and climb. At the same time the load per square foot of wing surface must be moderately low in order to have the seaplane airborne at low velocity. It is, therefore, specified as a prerequisite that with full load the seaplane should be loaded less than 10 pounds per rated brake horsepower, and the wing loading for biplane should be less than 7 pounds per square foot and for monoplanes less than 8 pounds per square foot of wing area. This assumes a fairly high lift wing section. If a designer proposes to use an unusual wing section, some allowance above or below these figures will be considered.

The details of track or trolley from which the seaplane is to be launched, provision for guiding and holding down, handling, recovering, launching car after plane has left, etc., are not yet definitely decided upon. Bidders are invited to submit sketches, data, and suggestions showing schemes they propose for accomplishing the above.

(*b*) *To start from the sea.*—In case a head wind is not available it is assumed that weather conditions are favorable and the seaplane will be lowered over the side and required to rise with its own power from the sea. The seaplane shall, therefore, be provided with a suitable hoisting sling, conveniently arranged for hooking on in a swell with ship rolling, readily accessible to the crew of the seaplane, and having a factor of safety over full load of six. Adequate pontoons or a boat hull with planing bottom must be provided. The seaplane shall be stable and controllable when running in a moderately rough sea. Particular attention must be given to the protection of the propeller from spray.

(*c*) *To land on the sea.*—The seaplane will always land on the sea and be hoisted aboard. This requirement is given the greatest weight, and bidders must show in their designs sufficient evidence of seaworthiness to convince the department that the design is worth consideration. Bidders are required to show a stable flotation system; secure against capsizing when at rest on a rough sea; provided with watertight subdivisions; a large excess buoyancy (for pontoons more than 150 per cent, for a boat hull more than 500 per cent); sufficient clearance under lower wings and tail to keep clear of breaking seas; means for towing consisting of a bridle or lizard secured forward at a suitable point for towing and led back to a point where the crew can conveniently reach it for securing a heaving line. Sufficient freeboard for a boat hull must be provided to avoid shipping water into the cockpit. The cockpit shall be further inclosed between watertight bulkheads to localize flooding. While it is realized that for any craft there will be a limiting sea which will swamp it, the purpose of this schedule is to call for the development of a type of maximum seaworthiness. Favorable consideration will be given to the provision for detaching the wings wholly or in part while adrift at sea. It is contemplated that this seaplane will sometimes land in very rough water, but will not be able to rise under such unfavorable conditions.

In case of a wreck, it is desired that the flotation elements will remain sufficiently intact and buoyant to float the crew until they can be rescued.

(*d*) *Airworthiness.*—In the air the seaplane shall be in proper flying balance, completely controllable, and in all respects a safe and reliable flying machine. The inherent stability shall be such that pitching motions die out naturally without the intervention of the pilot; the directional stability such that a given course can be held without undue effort; that on a turn if correctly banked the seaplane tends to hold this bank; that no abnormal motion is introduced by cutting on or off power.

(*e*) *Air performance.*—The bidder will provide the best speed and rate of climb consistent with other conditions here required. The proposals shall show calculations of the predicted performance in sufficient detail to show the assumptions made, authority for aerodynamic data, and general methods used, so that the entire calculation can be checked.

(*f*) *Handling and housing.*—The seaplane shall be constructed so as to permit ready assembly and disassembly of the principal parts to facilitate stowage aboard ship. Especial attention must be given to rapid and certain alignment of all fixed surfaces, if possible without need of adjustments. Folding wings or quick detaching wings are desired. The seaplanes will be housed in a restricted space, but must be in a condition for service in a minimum time, and in any case on not more than one-half hour's notice. Wing panels shall be less than 20 feet in length, and in general careful attention shall be given keeping over-all dimensions of all principal parts to a minimum. All control leads shall be readily accessible and so rigged that correct adjustment of slack is not affected by assembly and disassembly. Gasoline and oil piping and engine controls should be so rigged as to be unaffected by disassembly of the seaplane for stowage. The complete power plant should remain assembled as a unit.

Guarantees

Specific statements are required from bidders which each is prepared to guarantee as to—

(*a*) Weight empty, useful load, and full load of the seaplane complete in all respects ready for the air. These weights must be itemized, but totals only are to be guaranteed.

(*b*) Ability to fulfill the desired requirements as regards performance and characteristics as enumerated under paragraph 2.

Demonstration

To be carried out as outlined below, or as modified by agreement.

Getaway (paragraph 2*a*). From pier or from land by agreement as to length of run and wind velocity (contractor's risk, contractor's pilot.)

Water getaway (paragraph 2*b*). From a bay or harbor (contractor's risk).

Landing (paragraph 2*c*). Open sea.—*Navy pilot, Navy risk.*

Airworthiness (paragraph 2*d*). Demonstrated by Navy pilots as may be desired for verification.

Air performance (paragraph 2*e*). By contractor.

Handling and housing (paragraph 2*f*). The contractor to demonstrate time to take down and set up again with his own crew, and will fly the seaplane without further adjustments.

Load Definitions

In the air the seaplane shall carry:		Pounds.
(*a*) Two men		360
(*b*) Ordnance		60
1. Machine gun.		
2. Ammunition trays.		
(*c*) Instruments, etc.		45
Compass.		
Altimeter.		
Air speed meter.		
Oil pressure.		
Oil temperature.		
Water temperature.		
Inclinometer.		
Tachometer.		
Hand fire extinguishers (2).		
Tools, etc.		
(*d*) Miscellaneous:	Pounds.	
Wireless	85	
Food	10	
Sea anchor	10	
Heaving line	5	125
Signals	5	
Camera, etc.	10	
Intercommunication set	10	
Total fixed load		590
(*e*) Fuel and oil for at least two hours at rated full power.		
Total useful load		

The engine, fixed instruments, and special accessories and equipment will be supplied by the department or the bidder, as may be agreed upon. Proposals shall state in detail what is desired to have the department supply.

Penalties

Penalties to be fixed under the terms of the contract will be imposed for failure to meet the following requirements:

(*a*) Weight requirements.
(*b*) Time of delivery.
(*c*) Guarantees of performance under (*a*), (*b*), (*c*), (*d*), (*e*), and (*f*), of paragraph 2, as given under paragraph 3*b*.

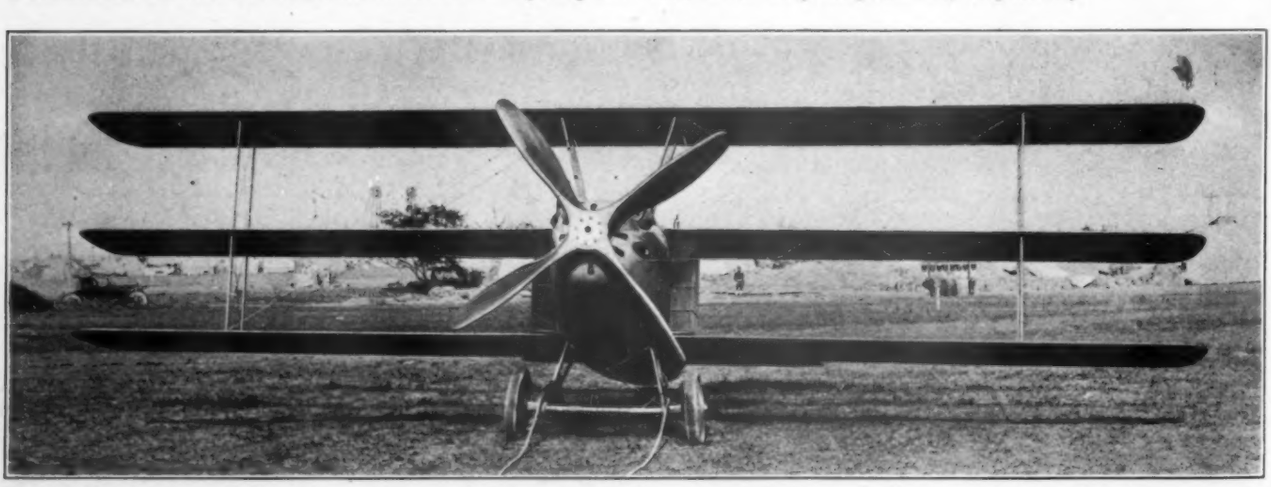
Further details in regard to the provisions and intent of this schedule may be had by consulting the Bureaus of Construction and Repair and Steam Engineering, Navy Department, Washington, D. C.

Copies of General Specifications No. 100 above referred to may be obtained upon application to the Bureau of Construction and Repair, Navy Department, Washington, D. C.

To be inspected at place of manufacture unless otherwise directed by the Bureaus of Steam Engineering and Construction and Repair.

The Curtiss Type 18-2 Triplane

The Curtiss type 18-2 triplane is a high-speed two-seater fighter of distinctly original design which promised to constitute a remarkable American contribution to the Allies' fighting air forces, had not the war come to an end through the armistice.



FRONT VIEW OF THE CURTISS TYPE 18-2 TRIPLANE

The wings of this machine have an equal span of 31 ft. 11 in. and a chord of 42 in.; they are set at an angle of 2½ deg., at 5 deg. sweepback, with no dihedral or stagger. The wing curve is a Sloane. The gap between the upper and the middle wings is 42 in., while that between the middle and lower wings is 35½ in. The wings are braced by one pair of interplane struts on either side of the body, and the customary flying, landing, and incidence wires. The upper wing is fitted to a center section supported by a cabane of four struts, sloping outwards, while the middle and lower wings are attached to the upper and lower body longitudinals, respectively.

The machine has an overall length of 23 ft. 3 3/16 in., and an overall height of 9 ft. 10⅜ in.

The wings have the following areas: upper, 120 sq. ft.; middle and lower, 87.71 sq. ft., each; ailerons (on middle and lower wings only), 21.58 sq. ft., each; which gives a total supporting surface of 309 sq. ft. The horizontal stabilizer is 14.3 sq. ft. in area, the vertical stabilizer, 5.2 sq. ft., the elevators, 6.51 sq. ft., each, and the rudder, 13.02 sq. ft.

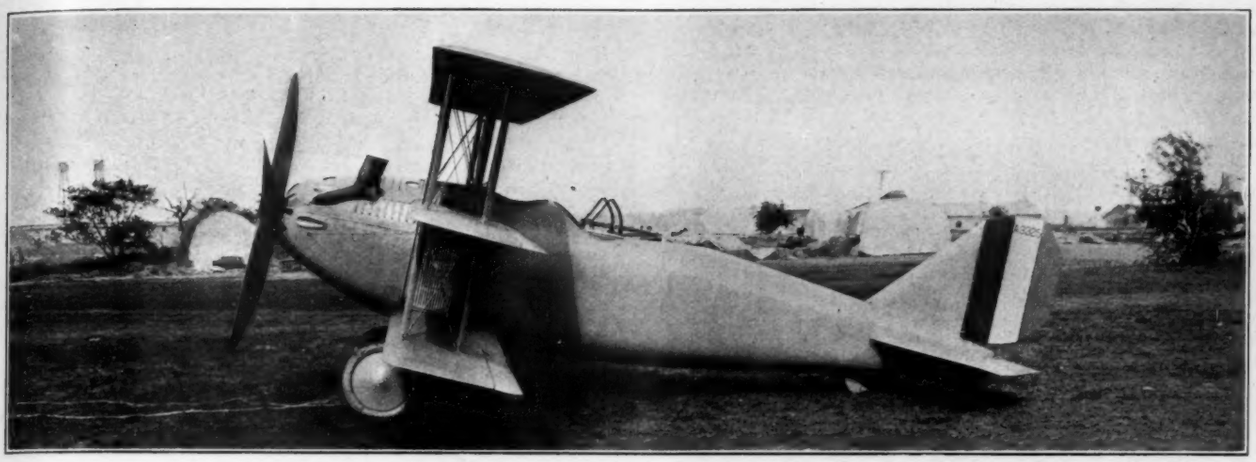
The engine is a Curtiss model K-12, which is rated 400 hp.

at 2250 r.p.m. and weighs 1.65 lb. per rated horsepower. The fuel consumption is 0.55 lb. per b.hp., and the oil consumption, 0.03 lb. per b.hp.; the total fuel consumption per hour is 36.7 gal. A complete description of this engine was printed in the Jan. 1, 1919 issue of AVIATION AND AERONAUTICAL ENGINEERING. The fuel tanks of the type 18-2 hold 67 gal.

Fully loaded, the machine weighs 2901 lb.; empty, 1825 lb.; the useful load is thus 1076 lb., which is apportioned as follows: Fuel, 400 lb.; oil, 45 lb.; pilot and passenger, 330 lb.; armament and accessories, 301 lb.; Total, 1076 lb.

From these figures the wing loading is seen to be 9.4 lb./sq. ft., and the power loading, 7.25 lb./b.hp.

The performances of the Curtiss type 18-2 triplane are extremely remarkable and confer upon it the distinction of being one of the fastest, if not actually the fastest, machine in the world. The high speed, in horizontal flight, is 151 m.p.h., and the low speed, 61.2 m.p.h.; the climbing speed is 13,125 ft. in 10 min.



SIDE VIEW OF THE CURTIS TYPE 18-2 TRIPLANE

Topographic Surveying by Aerial Photography

By Arthur Brock, Jr., and L. J. R. Holst

Maps made from aerial photographs may be grouped into two principal divisions, namely, plain surface maps and contour maps. The present article deals mainly with contour maps, since they embody features which render them especially valuable for civil and commercial purposes, and thereby tend to make topographic surveying by means of aerial photography one of the leading uses for airplanes in peace times.

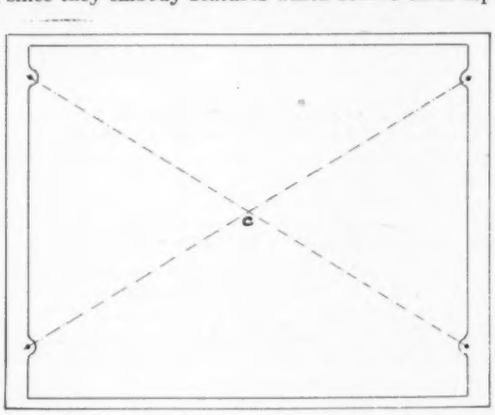


FIG. 1

In order to be useful for this work aerial photographs must fulfill three principal conditions:

1. They must form an uninterrupted series of views of which each one is a projection on a true horizontal plane of the actual land shown on it.

2. They must contain indications permitting to determine exactly which point of each picture was in the axis of the lens at the moment of exposure.

3. They must be taken at such intervals that each succeeding picture contains near its margin the spot of ground which is the optical center of the preceding view.

It is, of course, furthermore desirable that the order in which the successive pictures are taken be readily recognizable. This is most easily accomplished by numbering them in proper rotation after development, but before separating them in single units. This is noted merely as a time-saving precaution and not as an absolute requirement, since it is always possible to reconstruct the proper sequence.

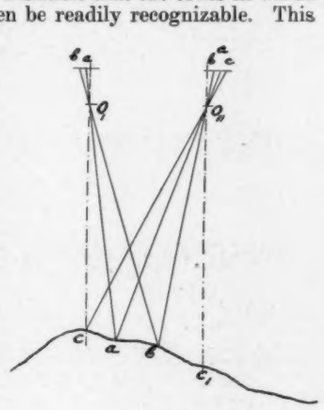


FIG. 2

The first of these essential conditions implies the free suspension of the camera so that the true vertical position of the lens, and the true horizontal position of the image-plane, be secured at all times, notwithstanding the swaying of the airplane.

The second condition is complied with in the Brock cameras in the following manner: The aperture plate of these cameras has a rectangular opening of 4 in. x 5 in.; on each of the four-inch sides are two inwardly projecting curves spaced 3.5 in. apart. In each of these four projections is a hole of 1/64 in., the four holes forming the corners of a rectangle which has the lens exactly in its center. These holes produce thus four dark points in white fields on the margin of each negative. The intersection of the two diagonals drawn in the rectangle so formed indicates the optical center of the view, illustrated in Fig. 1.

The third condition is complied with by the completely automatic operation of the Brock camera, and is speed regulation;

this is effected by a simple clockwork mechanism, working with constant spring tension during the entire period of operation of the instrument.

A series of photographs complying with these three principal conditions, and having been made at the same altitude level, will furnish prints which can be superimposed to form one continuous view of the territory covered by them; if such territory is entirely, or almost entirely, level they will then result in the so-called mosaic. For actual map-making it is, however, necessary to make use of the negatives themselves, and by careful triangulation to lay off on a drawing-board the more essential points of interest they contain, first on the scale of the negative, and later to transfer these points to existing maps by reducing the scale of the drawing to that of the map.

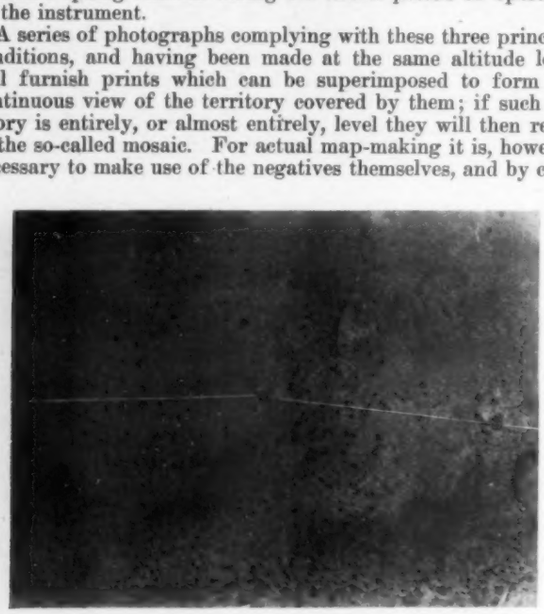


FIG. 3

For the process of making these drawings the knowledge of the actual scale of the negatives is not essential; it is, however, very essential to know whether or not the scale of two succeeding negatives is the same. Since it is always possible that the airplane should have passed through an air pocket between two succeeding exposures, differences in altitude, and consequently in scale, are always to be expected. They interfere with and, in fact, prevent the correct joining up of pictures made under these circumstances, and spoil the mosaic; but in no way do they diminish the value of the negative for map construction. The transposition of a base line obtained from any picture to the succeeding one will at once show what, if any, difference exists in the scale of these pictures by the difference in the length of the transposed base; and it is only necessary to increase or decrease all measurements taken on the latter negative in proportion of the dimension of the new base line to that of the transposed base.

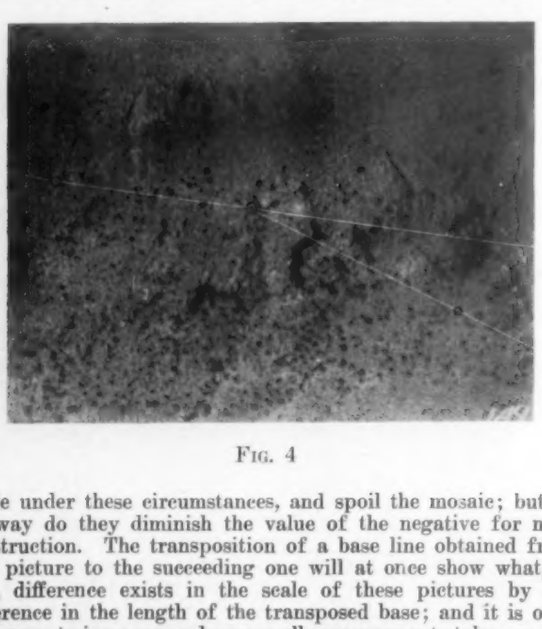


FIG. 4

Whenever the ground represented by a series of pictures is of mountainous nature, and especially when the difference in elevation of the territory depicted on successive negatives bear an appreciable proportion to the elevation of the airplane above this territory, the method previously described is no longer applicable because it then becomes impossible to conclude the relative scale between successive pictures from the distances separating corresponding viewpoints on the succeeding pictures. This will become clear by a study of Fig. 2, in which the camera and lens are shown above a mountain in two positions, but at the same altitude above sea-level. The points a and C on the slope thereof are of necessity much nearer together on the left-hand picture than on the right-hand one, since from the viewpoint O_1 the angle aO_1C is much smaller than the angle $aO_{11}C$ under which these same points appear from the viewpoint O_{11}.

Thus, notwithstanding the fact that the pictures obtained with the lens positions O_1 and O_{11} are of equal scale, no two points of the images will simultaneously cover each other. The two resulting pictures form, however, a "stereoscopic pair," and contain all the required data from which the object itself can be reconstructed; the difference in elevation, as well as the relative location in plan view, can be ascertained with great accuracy by a method now to be explained.

Further inspection of Fig. 2 will make it clear that the point a could be moved either upward or downward along the line aO_1 without thereby changing the position of the image of any of these points on the plate above O_1; in other words, the image point A on this plate can only indicate the direction in which the object point a was seen from the lens point O_1, but does not indicate its distance from O_1. The same applies to the object point B, which can be moved up or down along the line CO_1 without changing the location of the image point B on the plate above the lens point O_1; since the object points a and C have been chosen arbitrarily, we can apply this consideration as a general rule and say that *the location of any image point determines the angle of view under which the lens observed the corresponding object point, but not the distance at which this object point is located.*

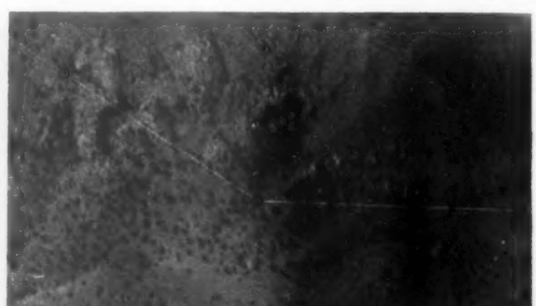


FIG. 5

Let us now see what influence the shifting of the object points a and C along the lines aO_1 and CO_1 will have on the image produced by them on the plate above the lens position O_{11}. It will at once be evident that when the object point a should move upward along aO_1 its image would travel away from the vertical through O_{11}, and that it would get nearer to that vertical whenever the object point a would descend along the line aO_1. Furthermore, it can only be where it is shown in Fig. 2 so long as the position of both the object point a and the lens point O_{11} remain as they are in Fig. 2. This applies with equal force to the object point C, and hence also to any other object point. If we thus can reconstruct the correct relative position of the two lens points O_1 and O_{11}, we will also be able to reconstruct the actual elevation of the points a and C, and of any other points depicted, by determining the directions under which these points were seen from the successive lens positions O_1 and O_{11}, since the intersection of these directions is the actual elevation of these points relative to the points O_1 and O_{11}.

In Fig. 2 are shown the two perpendiculars passing through the center of the lens in the positions O_1 and O_{11}. Since the lens is always supported in the true vertical, and the film or plate in the true horizontal plane, these vertical lines are the optical axis of the lens, and the intersection of this axis with

the picture is the optical center of the picture, and represents, of necessity, the object point situated at the base of the lens perpendicular or axis. If we thus can determine in each picture which point thereof is in the optical axis, we will know the exact point above which each succeeding exposure was produced. This leads us back to the real requirement of the special conditions to be fulfilled by pictures in order to be useful for map-making, namely, *each picture must carry means to disclose the point located in the axis of the lens at the instant of exposure.*

These means are shown in Fig. 1, and their practical application in Figs. 3, 4 and 5, and consist of four round spots in the margin of these negatives. As already explained, the intersection of the diagonals drawn through these points locates the lens axis, and hence the position of the camera over the ground when the picture was exposed; these points are indicated in Figs. 3, 4 and 5 by small circles.

The number of exposures per minute required for making contour maps of mountainous ground is larger than for flat map work; or, in other words, the exposures are made at less distance apart. This is to insure that each picture shall contain as much of the previous picture as is necessary to include the foot point of the lens axis of the previous picture. An inspection of Fig. 4 discloses its own center as well as the centers of Figs. 3 and 5, because since Fig. 5 must embrace the center of Fig. 4, the latter will also of necessity embrace the center of Fig. 5. Thus, all through a continuous series of such pictures, each one will contain the centers of both adjoining ones, and only the first and the last of each series will contain only one center besides its own.

Let us now imagine a perpendicular erected in the optical center of each picture, and the length of the perpendicular made equal to the focal length of the lens, as illustrated perspectively in Fig. 6, which represents negative Fig. 3, and let us call point O_1 the lens point.

By careful inspection of Fig. 3 we can find on it the image point which corresponds to the optical center of negative, Fig. 4. We locate this point at C_1 in Fig. 6. It will then be obvious that the line CC_1 indicates in plan view the direction in which C_1 is located relatively to C, and that the angle CO_1C_1 is the angle under which the lens, when exposing Fig. 3, saw the footprint of the perpendicular passing through the lens in the position in which it took picture, Fig. 4.

Fig. 7 illustrates in similar perspective the angle under which the footpoint of the perpendicular O_1C appeared to the lens when picture, Fig. 4, was exposed. Although, as formerly explained, the distance CC_1 in negative, Fig. 3, differs, or, at least, can differ, from the distance C_1C in negative, Fig. 4, the directions CC_1 and C_1C in these two negatives are the same, and the circumstance that they appear differently on the negatives indicates merely that the airplane was headed in a different direction at the instant of the two exposures producing these negatives.

If now the actual elevation of O_1 over the object point C, Fig. 8, is known, we can draw on our drawing-board, to any desired scale (for instance, 3 in. to 1000 ft.), the actual relative location of O_1 and the object point C, as illustrated in Fig. 8. Let us now reconstruct on the latter the angle CO_1C, then the point C must lay somewhere along the inclined leg of this angle. An inspection of Fig. 2 shows that the angle O_1CO_{11} is the same as the angle $CO_{11}C_1$, since O_1C and $O_{11}C_1$ are parallel. We therefore now reproduce the angle $CO_{11}C_1$ as measured from Fig. 7 upward from the point C, and will then know that the lens O_{11} must have been somewhere in the slanting leg of this latter angle, since only from points in this line the angle $CO_{11}C_{11}$ can have been formed. It remains thus to find a second point from which the angle to the lens O_{11} can be determined to finally locate this lens, and it becomes therefore necessary to know not only the location of the lens O_1, over the point C, but also its height above a second point visible in the negatives, Figs. 3 and 4.

We can also express this condition by stating that it is necessary to know the difference in elevation between two points both appearing in the first picture as well as in the second one. We assume for the purposes of this explanation that the point a in Fig. 9 is this second point, and that it is 50 ft. below C.

In Fig. 9 the point a is drawn 50 ft. below the horizontal plane passing through C on the scale of our drawing. We now locate the point A on Fig. 6, project its location in plan view onto the line CC_1, which represents the plane of the drawing, and measure the angle CO_1C. We reconstruct this angle downward from O_1 and on the other side of OC_1, since C is located on the other side, and thereby find the location of the point a as projected on the plane of the drawing. We next locate the point a on Fig. 7, again project it onto the line C_1C of that negative and find the projection to intersect with the line C_1C in the point C. We now construct on the drawing a vertical through the point a, Fig. 9, and reconstruct the angle $CO_{11}C_1$ as taken from Fig. 7 and upward from the point a. The slanting leg of this angle intersected the upward slanting line which passes through C in the point O_{11}. Since this is the only point from which both the points C and a can be observed under the angles at which they appear in Fig. 7, we have thereby located the second lens position O_{11} in distance as well as in elevation relatively to the first lens position O_1 without having had recourse to any question of scale; hence the effects of varying altitudes of succeeding exposures are automatically taken care of. We can now draw a vertical through O_{11}. This line will then represent the axis of the lens, or the lens-perpendicular at the second exposure, and consequently the intersection of the

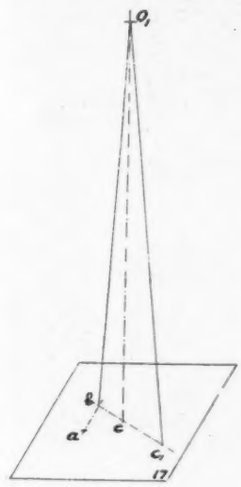


FIG. 6

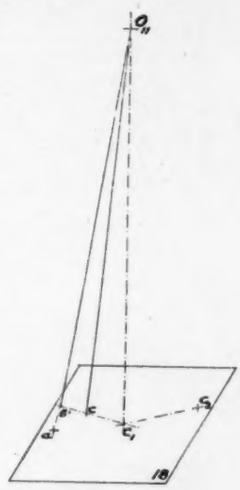


FIG. 7

line from O_1 to C_1 with this vertical will determine the footprint C_1 thereof, and mark its elevation relative to the points a and C already located. It also determines the actual distance between the points C and C_1.

Further inspection of negative, Fig. 4, will show that the direction of the center line of Fig. 3 to Fig. 4 differs from the direction Fig. 4 to Fig. 5. Thus when proceeding in an entirely similar manner to locate O_{111} and O_2, etc., the plane of the drawing will represent each time the vertical plane passing through two adjoining lens perpendiculars such as C, C_1, or C_2 and C_3. Any distances, therefore, measured horizontally between C_1 and C_{111}, and likewise between any other two adjoining verticals, will be correct; but distances between C and C_{11} and other points in different planes of projection are less in their actual value to an amount depending upon the angle made by the lines CC_1 and C_1C_{11}, etc. It is, however, most practical not to consider these differences until the elevation of all desired points have been determined and to ascertain their location in plan view afterward.

The method before explained produces thus primarily the exact relative location in space of the successive lens-points and the footprints of the perpendiculars at the instant of the succeeding exposures, and it will thus be frequently necessary to determine the location of points situated at some distance from the footpoints of the lens-perpendiculars. This is accomplished by projecting such point on each of the two pictures on which it appears on the line uniting the optical centers of these pictures. The angles formed by the projected points so found with the lens-points of each picture are then reproduced on the drawing in the manner already explained, and the resulting intersection will indicate the elevation of the projected points relative to the already established footpoints of the lens-perpendiculars, also its location in space.

It will frequently happen that a point of interest appears on three successive pictures. This circumstance may be used to check up the drawing, as it is evident that when a point

appears on negatives, Figs. 3, 4 and 5, the determination of its elevation can be made as well by combining the angles obtained from negatives, Figs. 3 and 4, as by combining those of Figs. 4 and 5, and that when the results are correct they must tally. It should be borne in mind, however, that when applying this check we will find one point situated between perpendiculars C and C_1, and another point situated between perpendiculars C_1 and C_2. A glance at Fig. 9 will explain this. It shows that instead of producing the actual point A, the process has yielded the projections of this point on the vertical planes CC_1 and C_1C_{11}, which projections themselves are different points, though of the same elevation, as the point A itself. The combined reconstructed plan view of such pictures will result in

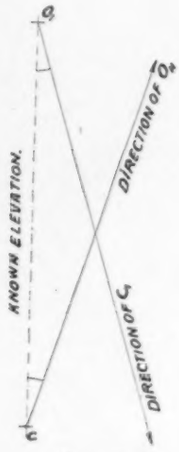


FIG. 8

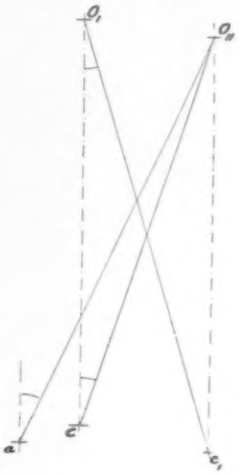


FIG. 9

only one location of the point A, whether it be determined from the first, second or the third negative.

It will be noted in the foregoing description that when a point appears on three successive pictures it is possible to verify the location of such a point definitely. In other words, such a system of mapping permits the use of control points, which are also points for verifying the intermediate pictures in their correct location. By this method commercial airplane photographic mapping is possible, and only by this method is it possible. It is entirely useless to attempt to determine property lines without control points which are close by and which will not be lost. And further, it is not enough merely to locate a given point in plan view without giving either a series of contour lines or without giving the elevation of such a point with reference to sea level or any other suitable datum. All this becomes the more important when photographic mapping is considered as a commercial possibility for civil engineers and surveyors. The work to be done ordinarily by private enterprise consists of the location of new lines of transportation, either railroads or waterways, and in none of these three cases is a photograph of any particular use unless it assists the surveyor in determining elevation as well as location, and can be checked up by existing control points.

Airplane surveying, when commercially applied, will undoubtedly be used in co-operation with the photo-theodolite; this instrument is essentially a camera which is accurately leveled and which photographs along certain angles of a determined base plane. This system of surveying is specially suited for mapping points situated far apart, since it is not possible for the airplane camera to embrace in one exposure such considerable distances excepting under certain unusual conditions.

The future alone will tell to what extent airplane photography is commercially feasible. In the present day such work is not commercially done. In point of fact, the actual method of photographic surveying from airplane is very much simpler than the photo-theodolite of transposing planes. But, although the photo-theodolite originated about 1850, it has only come into common use within the last twenty-five years, more as a result of a lack of understanding of its function than by any limitations of the process. Prints are not used or should not be used for the purpose of making surveys, for the amount of detail information obtained by surveying in this way is so far in excess of the regular methods that unless the engineer or surveyor is experienced he is more apt than not to be hindered by an unnecessary amount of information.

On the other hand, by the use of instruments for the purpose of reconstructing angles, the system of airplane surveying can be brought to a point where it is extremely rapid for areas which are too large for the ordinary transit and which are too small for the photo-theodolite. This last remark requires qualification because the photo-theodolite process can be used for surveying very small areas. Unfortunately, however, it does not lend itself to rapid work, particularly if detailed information is required, and such information would take considerably longer time to be worked out than when obtained with an airplane camera.

It is perfectly feasible to make complete maps for roads, waterpower and irrigating systems, and also to determine the easiest general plan for building roads through an unexplored country. Either application is today within the possible reach of contracting companies owning airplanes and maintaining a staff of flyers. The last application is especially possible where railroad lines are to be run for long distances through unknown country. It is not believed that an individual can use an airplane surveying camera on account of the cost of operating the required airplane. And since the expense of photographic surveying does not come from the use of the camera, but entirely from the use of the airplane, a more or less continuous use for photographic mapping would bring the expense or a photographic flight within reasonable limits.

The Government, with the airplanes at its disposal, can today do photographic surveying on a very large scale with comparatively small expense as compared to the usual method. It can also re-survey the older parts of the country and correct some of the earlier surveys in a way which has not been possible heretofore.

Experimental Aeronautical Engineering

Beginning with its issue of March 15, 1919, AVIATION AND AERONAUTICAL ENGINEERING will publish in serial form Part III of the Course in Aerodynamics and Airplane Design by Alexander Klemin, formerly Instructor in Aeronautics at the Massachusetts Institute of Technology and, during the war in charge of aeronautical research work of the Air Service at McCook Field.

Parts I and II of this course, which dealt with aerodynamical theory and data, and with airplane design, respectively, were printed in Volumes I and II of AVIATION AND AERONAUTICAL ENGINEERING and have since been published in book form. Part III will deal with experimental aeronautical engineering.

The war has witnessed a tremendous development of the experimental branch of aeronautical engineering. Broadly speaking, the construction of every new machine is an experiment even if no systematic tests of any sort are carried out, and the testing is merely that of usage as in the early days. In a more restricted sense, experimental engineering is that technical branch of aeronautics which involves the systematic testing of an airplane or its component parts for the purpose of improvement or innovation, and this from the three principal viewpoints of (a) structural strength, (b) performance, and (c) stability and controlability.

This work, although it may be concerned with the very latest developments, is entirely distinct from the purely aerodynamical research work of the physicist. It is engineer's work and should be carried on by engineers, even though the physicist may give the scientific foundation or help in devising accurate instruments. A very complete technique has grown up in this respect, and it is with the principles and utilization of this technique that Part III of the Course in Aerodynamics and Airplane Design will deal.

Hitherto work of this character has in the United States been largely restricted to the Army and Navy Air Services. With the advent of peace it is hoped that this work will be taken up in earnest by the aircraft industry. A full employment of the tools now available, skilfully used by a great number of men, will lead to the solution of the most pressing problems which confront the development of aeronautics.

As a sequel to Part III there will be printed Part IV, which will deal with materials of airplane construction.

A series of articles by Alexander Klemin and Frank W. Caldwell on the theory, construction and design of airscrews will be also published from time to time.

Design of Airplane Struts*

By W. H. Barling and H. A. Webb

The failure of struts under end load is due to two causes, crushing, due to direct compression, and excessive bending, due to elastic instability. In a general way, we may say that the end portions of the strut tend to fail by crushing and the middle portion tends to fail by bending, but we cannot make a rule to decide where the middle portion ends and the end portions begin, because both causes are really operating simultaneously all along the strut, and we can only form a vague impression of their relative importance at various sections of the strut. A parallel strut, for instance, unless it is very short, will fail by bending at or near the middle, and the end portions will show no signs of crushing; so we may fairly infer that

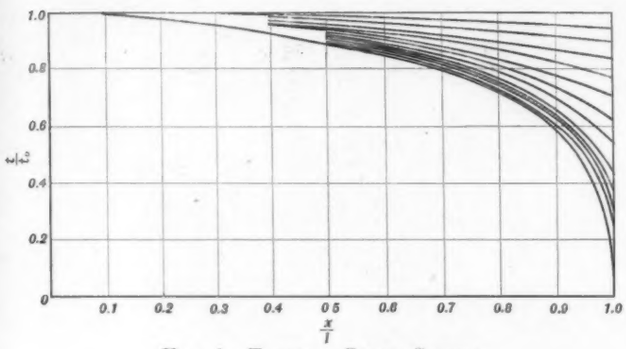


FIG. 1. TAPERED SOLID STRUTS

weight can be saved in a solid wooden strut without much loss of strength by tapering the ends; and that on the whole the efficiency of a strut, as measured by the ratio of crippling end load to weight or (resistance + m weight) where m† is a fraction, can be improved by tapering. If, however, the taper is too severe, the ends of the strut will crush before the middle portion shows signs of failure by bending. And if the taper is gradual, but incorrectly designed, it will be found that the strut will fail at or near some definite section (it might be, for instance, at three-quarter length), that being the section which, under the combined influence of direct compression and elastic instability, is weakest.

Nearly 150 years ago the great French mathematician, Lagrange, considered the problem of tapered struts. He was not interested in airplanes, so far as we know, but in ancient times Vitruvius had recommended architects to taper their columns, and Lagrange noticed that many architects did so; but when he asked them why, they had no better reason to give him than an analogy from the shape of the human body. This was inconclusive, since different people of the same height have very different tapers, so Lagrange decided to examine the problem mathematically. He considered several tapers, and found they were all worse than useless. This conclusion was correct, and he was too good a mathematician to make a mistake on such a point. But then he inferred that tapering was essentially bad, and that the parallel strut was the best possible.

This inference was wrong; Lagrange had not drawn his conclusion from a large enough range of examples.

A badly tapered strut may be much worse than a parallel one, an error present in most airplanes earlier than 1915, and even in some present-day machines.

In the summer of 1914 the authors deduced a strut shape which, both by theory and by test, gave considerably better results than parallel struts of the same weight. Struts of this shape have been used in great quantities ever since, R.E.7 being the first machine. Considerable experience and work (1915) on these struts have led to the conclusion that no appreciable improvement in shape can be made.

If f lb. per sq. in. is the maximum stress that we decide to allow in the strut, it seems likely that the best strut is one in which, as the end load rises and the strut deflects, the maximum stress at *every* section of the strut reaches the value f simultaneously, since such a strut would in theory, given uniform material and perfect construction, fail at every section at once. This assumption is not quite obvious, but we established it rigorously for solid struts by means of the calculus of variations in 1915; the practical results of these tests are shown in Fig. 1.

The taper depends on the load the strut has to carry, a sharper taper being used on a lightly loaded strut. Correct tapering saves 13 per cent of weight, and, if the struts are exposed to the air, 8 per cent of resistance, on all except heavily loaded short struts.

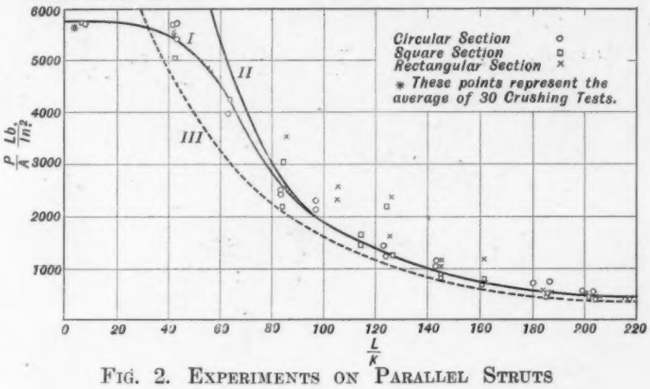


FIG. 2. EXPERIMENTS ON PARALLEL STRUTS

Many such struts have been tested from time to time, and are found, as a rule, to develop cracks on the compression face at several points along the length simultaneously in confirmation of the theory.

The Effect of Lateral Wind Load on Struts

When an airplane side-slips, the lateral wind load tends to increase the deflection of the struts. If allowance is to be made for this in design, no sensible alteration in the taper is necessary, and allowance can be made by designing the strut to support a somewhat higher load than would otherwise be required.

As an example, if the forward speed of the airplane is 130 m.p.h., a stream-line spruce strut 6 ft. long, with a crippling load of 2000 lb., would have its crippling load reduced 12 per cent by side-slip. Stiffening the strut to enable it to support side-slip would add 6 per cent to its weight and 3 per cent to its resistance. On stiffer struts the effect of side-slip is much less. Probably in the design of the wing struts of fast scouts side-slip should be considered; in slower machines it is not at present important.

Short Wooden Struts

It is well known that Euler's formula for the crippling load of *parallel* struts, namely,

$$P = \frac{\pi^2 EI}{L^2}$$

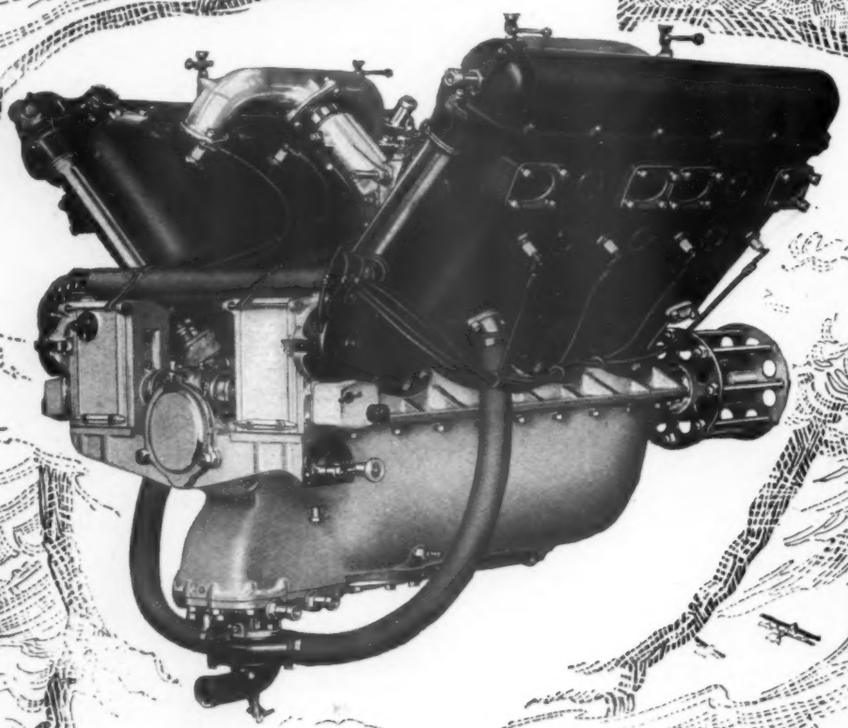
which is based on elastic instability only and neglects crushing, gives good results for long struts, but gives too high a value of the crippling load for short struts. The discrepancy is commonly attributed to two causes, namely, initial curvature of the strut, due to warping, which is probably more noticeable in wood than in metal; and eccentricity of end load, which probably depends mainly on the nature of the end fittings. It can be shown mathematically that both these causes have a small effect on the crippling load of long struts and a large effect on the crippling load of short struts. Further, it was pointed out by Professor Perry in 1886 that the effects of initial curvature and of eccentricity on the behavior of the strut are mathematically similar, and may both be allowed for by the assumption of a certain fictitious eccentricity of end load to be determined by comparing the results of experiment and calculation.

To test this theory, and also to check the values of E and f

* Paper read before the Royal Aeronautical Society.

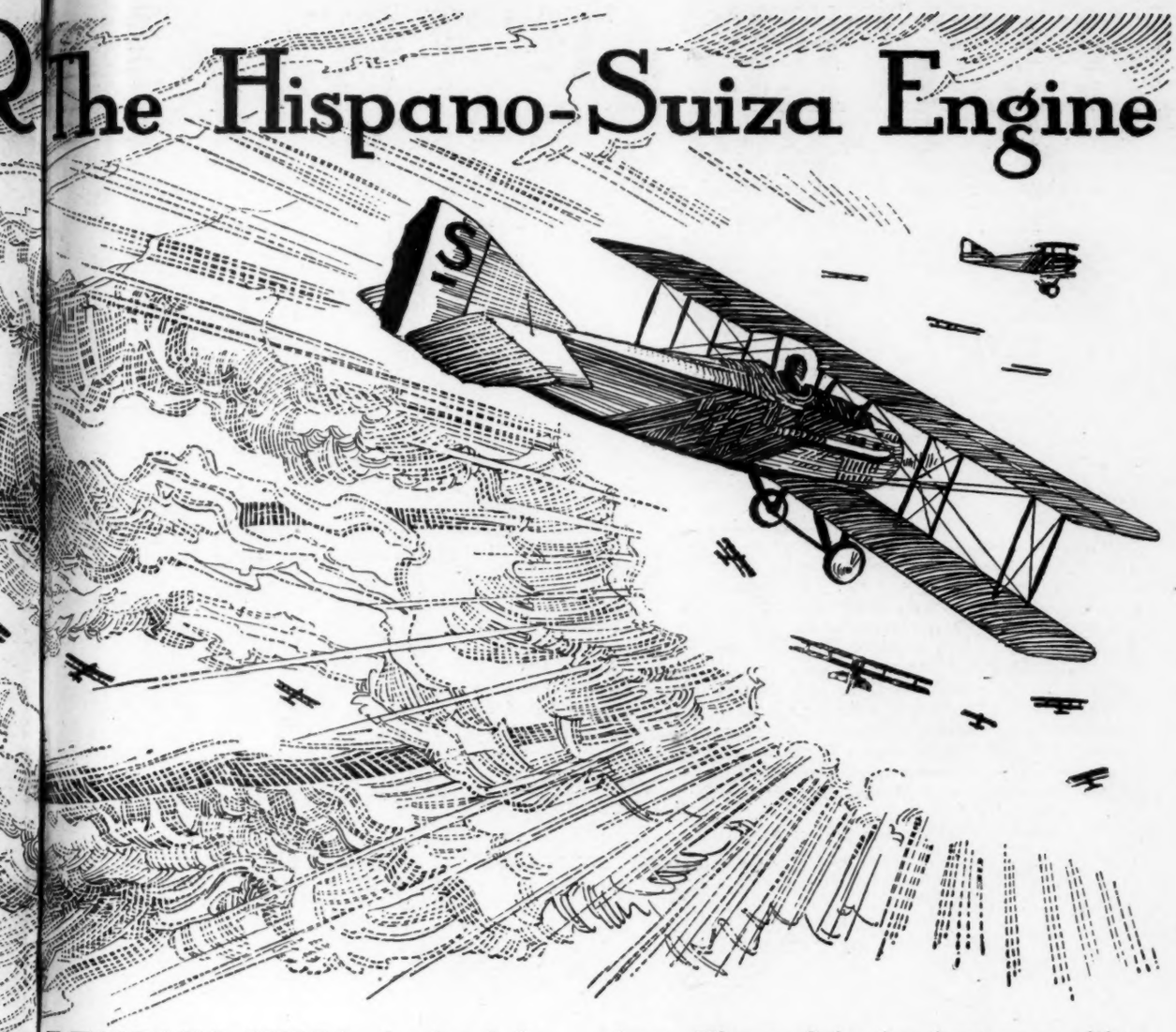
† The value of m depends on the case under consideration. A common value is 1/6 or ¼.

MASTER OF THE AIR



WRIGHT-MARTIN

The Hispano-Suiza Engine



HISPANO-SUIZA developed its world-wide reputation during the early stages of the Great War.

The very peak of its efficiency was reached when the Air Forces of France and England were gaining that now well-understood "Air Supremacy" at the end of the second year of the Struggle. It was then that France's most noted aces, Guynemer, Fonck, Herteaux and others were establishing their marvelous records in the small, swift, deadly one-seater planes—the "Spads"—which were made possible only because of the speed, flexibility and versatility of the Hispano-Suiza Engine.

Since then, in the powering of the one seaters, the two and three seaters, and the heavier bombing machines and hydroplanes, Hispano-Suiza has kept pace with the development of the aeronautical activities of several nations. Hispano-Suiza has reached that point of efficiency which would have been impossible, except where a fundamentally great engine had been developed by the most progressive brains of the industry.

These are the reasons for the mastership of Hispano-Suiza.

Wright-Martin
Aircraft Corporation
New Brunswick, N. J., U. S. A.

See The Hispano-Suiza Exhibit at the Aero Show, March 1-15, 1919

AIRCRAFT CORP'N.

used in design, experiments were made in 1916 at the Royal Aircraft Factory on the crippling loads of fifty parallel spruce struts of circular, square and rectangular sections, and of widely varying dimensions. The lengths of the struts varied from 1 to 4 ft., and their cross-sectional areas from ½ sq. in. to 2 sq. in. In the rectangular sections the ratio of the sides varied from 2 to 1 to 4 to 1. The struts were tested with pin-jointed ends, the fittings being specially constructed to insure that the load should be as nearly central as possible. The results of the tests are shown graphically in Fig. 2.

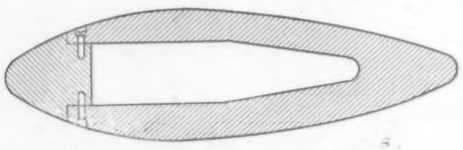


FIG. 3. HOLLOW WOODEN STRUTS

It may be noticed that:

(a) Euler's formula, represented by Curve II, gives good results for long struts.

(b) Gordon's formula, represented by Curve III, does not represent the facts.

(c) The Curve I represents a fair average of the facts, and is drawn from the theoretical formula for an eccentrically loaded parallel strut, *on the assumption that the eccentricity is proportional to the least diameter of the strut.* We claim that this assumption is justified by the R. A. F. experiments. That the *real* eccentricity of load should be proportional to the diameter of the end fitting seems likely enough. But it must be remembered that we are dealing with what is probably a fictitious eccentricity; in fact, an empirical coefficient, depending on other things besides end fittings; and that is why we have appealed to experiment for justification.

Next we propose to assume, for the design of short *tapered* struts, that the eccentricity is proportional to the diameter of the end fittings, for all fittings of a given type, *whether the strut is parallel or tapered.*

As regards the real eccentricity, this assumption seems reasonable. As regards other causes, such as initial curvature, it is not obvious. But it must be remembered that *the tapered strut, having smaller ends, has lighter fittings than the parallel strut,* and as we propose to make no allowance for this point, it is probable that our assumption does not, on the whole, favor the tapered strut over the parallel strut; rather, if anything, the reverse.

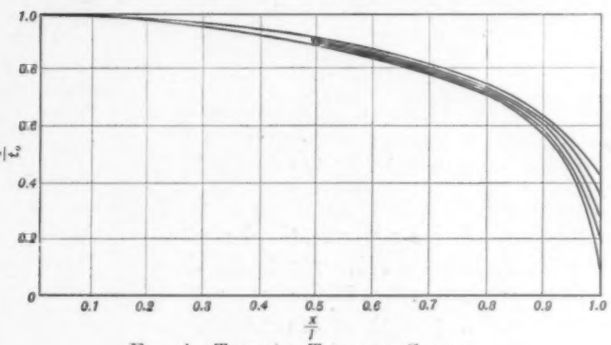


FIG. 4. TAPERED TUBULAR STRUTS

Another interesting point in Fig. 2 is that struts of rectangular section, shown by crosses, are on the average, though there are exceptions, stronger than struts of square or circular section. Probably this is due to non-uniformity of material. The square and circular struts deflect in their weakest direction, if all directions are not equally strong. The rectangular struts have their direction of deflection prescribed for them, and this is naturally not usually, *though it is sometimes,* the direction in which the material is weakest. For the same reason tests on stream-line struts, because they have their direction of deflection prescribed for them, give on the average, *though there are exceptions,* better results than tests on square or circular struts; but it would be rash to rely in design on the apparent extra strength of stream-line struts, which must be regarded as exceptional, though such exceptions be more frequent than the rule.

The correct taper for short struts is shown in Fig. 1. Tapering saves 12 or 13 per cent of weight on all struts whose length is more than 20 diameters.

It should be noticed that the crippling load of the tapered strut is not stated in Fig. 1 because it depends on the eccentricity. But the designer is presumed to know from experiment the crippling load of the parallel strut that this tapered strut is designed to replace.

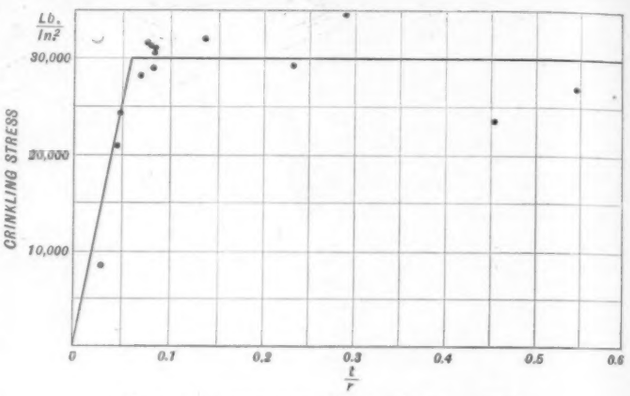


FIG. 5. ANNEALED MILD STEEL TUBES

Body Struts

A common type of body struts in a tractor machine consists of a parallel middle portion with conical ends. For the best results the parallel portion should be 40 per cent of the total length of the strut. If correctly designed, these struts will be nearly 10 per cent lighter than parallel struts.

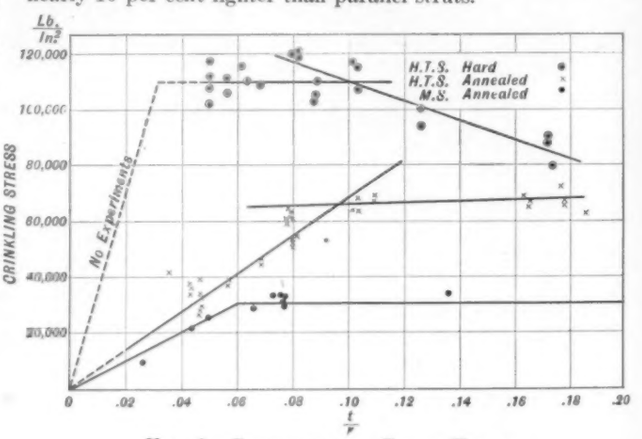


FIG. 6. CRINKLING OF STEEL TUBES

Hollow Tapered Struts

An efficient type of strut for large machines is a tapered wooden strut containing a parallel or untapered hole running the whole length of the strut.

Struts of this type were first designed by the authors toward the end of 1915, and have proved satisfactory.

As most hollow wooden struts warp bady, the authors then devised and used the construction shown in Fig. 3. Here the two different pieces forming the strut are still symmetrical about the center line 00 and have inherently little tendency to warp perpendicular to 00. The strut is too stiff to warp about its other axis. The hollow portion in such struts should preferably be parallel along the length for manufacture reasons. With such struts the end fittings may be placed inside in the case of large machines.

Another type of strut that is theoretically efficient is a tapered tubular strut of uniform gage, whether made of metal or of layers of plywood. The correct taper is shown in Fig. 4. These struts are 10 per cent lighter and have 10 per cent less resistance than parallel struts of the same material and gage. It may be doubted, however, whether struts of this type will

ever come into general use, as special skill and machinery are required for their manufacture.

Faired Steel Tubes

This is a popular form of strut, as it allows simple end fittings and is cheap.

A point of considerable importance sometimes overlooked is that the fairing itself generally strengthens up the tube by a large percentage. It often pays to use fairly thick, well-attached fairings, and to rely on them for strength. Pilots, mechanics, and others require to be educated on this point, as it is popularly supposed that fairings are for reduction of resistance only. The faired steel tube is not fairly treated if this view be taken.

An important point in connection with the use of annealed steel tubes for struts, whether M. S. or H. T. S., is what is called the "crinkling stress." The stress f is intended to mean the stress at which the relation between stress and strain departs appreciably from the straight line law. This is sometimes identical with the elastic limit of the material, but in hollow steel structures it is often not identical; and then for f the value of crinkling stress must be taken.

For example, tubes in compression fail by the formation of circular, oval or polygonal crinkles, generally close to the ends of the tube, and by the crinkling stress is meant the stress in lb. per sq. in. at the beginning of the formation of the first crinkle, and this may occur at a stress below the elastic limit of the material.

The result of tests made at the Royal Aircraft Factory in 1914 on short annealed mild steel tubes is shown in Fig. 5. The tests are plotted on a base of

$$\frac{t}{r} = \frac{\text{thickness}}{\text{mean radius}}$$

and it will be noticed that if $t/r>.06$, the crinkling stress is 30,000 lb. per sq. in., but that if $t/r<.06$, the crinkling stress drops rapidly by a straight line law. For instance, for a tube of 3-in. diameter and 22 gage, the crinkling stress is only about 10,000 lb. per sq. in. The importance of this is obvious, since it is to the interest of designers, if it were not for crinkling stress, to use thin tubes to get greater stiffness without increase of weight.

As the cause of crinkling was obscure, and as data for the design of H. T. S. struts were urgently needed, Mr. Garnett, the Principal, and Dr. Field, Professor of Mechanical Engineering at the Manchester School of Technology, kindly undertook to test in their laboratory tubes supplied by the R. A. F. An account of these tests was published last October in the "Proceedings of the Institution of Civil Engineers," in a paper entitled "The Failure of Short Tubular Struts of High Tensile Steel," by Popplewell and Carrington. This paper should be read by every designer who uses H. T. S. tubes in compression.

The tests were performed with an elaboration and an attention to detail that reflect great credit on the care and patience of Mr. Carrington, the experimenter, and make the paper of classical importance.

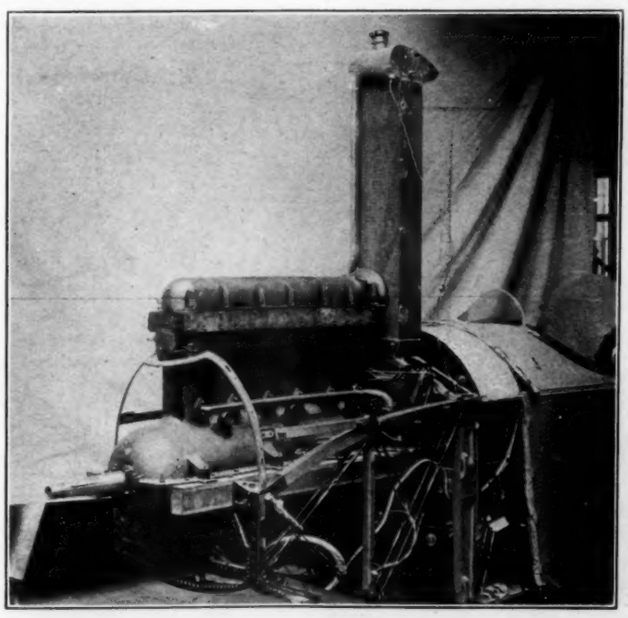
The results on annealed tubes are shown in Fig. 6, given here by the kind permission of the authors of the paper. It will be noticed that the diagram is similar to that for mild steel, except that the critical region occurs when $t/r = .1$ instead of .06. If $t/r>.1$, the crinkling stress is 65,000 lb. per sq. in. If $t/r<.1$, the crinkling stress drops rapidly by a straight line law. For instance, it would be rash to use an annealed H. T. S. tube of 3 in. diameter and 22 gage in circumstances requiring a crinkling stress in excess of 12,000 lb. per sq. in.

The Curtiss Model K-6 Aircraft Engine

The Curtiss Model K-6 aircraft engine is of the vertical type, with six cylinders arranged in line; it is rated 150 hp. at 1700 r.p.m. The bore is 4.5 in., the stroke, 6 in. The cooling is effected by a centrifugal water pump, and lubrication by pressure feed; two high tension magnetos are used for ignition. The carburetor is a Duplex type Ball Aero Carburetor. The engine weighs without oil or water 417 lb., which gives a dead weight per rated horsepower of 2.78 lb. The gasoline consumption is 0.55 lb. per b.hp.; the oil consumption, 0.03 lb. per b.hp.

The installation dimensions are the following: overall length, 63 in.; overall width, 22⅜ in.; overall depth, 39¼ in.; width at bed, 15¾ in.; height from bed, 24⅛ in.; depth from bed, 15⅛ in.

General Design—The form of construction adopted on this engine gives a minimum center distance between cylinders, together with careful placing of the accessories, makes the engine compact and easily placed in the airplane body. At the same time the accessibility of the various parts is such that sub-units may be readily inspected or overhauled without disturbing the engine in its mounting on the airplane body.



CURTISS MODEL K-6 ENGINE MOUNTED TO AN AIRPLANE

Crank Case—The crank case is cast of alloy aluminum with the cylinder water jackets integral; extreme rigidity and absolute alignment of parts are thus maintained, as well as an appreciable saving of lightness gained. The lower half of the crank case, containing the oil pan, is securely bolted to the flange on the center line of the crank shaft, which also adds to the stiffness of the assembly.

Cylinders—The cylinders are rough-machined from a special analysis hydraulic steel forging, heat-treated and finish-machined all over, with the cylinder head forged integral. This type of cylinder insures maximum strength with minimum weight; the water being in direct contact gives uniform efficient cooling with minimum cylinder distortion.

Connecting Rods—The connecting rods are forged from specially selected steel and are carefully heat-treated. They are machined all over, and, when finished, are carefully balanced as to weight, not only with each other as a whole, but as to each end.

Crank Shaft—Each crank shaft has a test piece taken off which goes to the Curtiss laboratories, where all its characteristics are determined to insure that each forging is up to specifications before any machining is started. The inspection of the finish shaft comprises a minute inspection for checks or surface flaws, a static balance test and finally a running balance test. The crank shaft is tapered and keyed to receive the propeller hub, which is drawn tight with a differential thread nut at end of shaft.

Bearings—The crank-shaft and connecting rod bearings are reamed, which eliminates the variations that are unavoidable with hand-scraped bearings and permits replacements without fitting, as both the inside and outside diameters of the bearings are held so close in manufacture that new ones will drop more accurately in place than would be possible to fit them by hand.

Valve Gear—The new valve gear used on the model K-6 is a distinct advance over previous engines. A light cam follower relieves the valves of any side strains due to cam action, and provides means of easy adjustment of clearance. As the cam shafts are directly over the valves, all rocker arms, push rods, etc., are done away with and the whole assembly is absolutely oil tight.

Ignition—Double ignition from two separate magnetos gives a more instantaneous explosion, which at high engine speed is necessary to develop high mean effective pressures. The spark plugs are located near the intake valves, on the upper side, to guard against fouling and insure absolute ignition. The wire assemblies are enclosed in insulating covers of micara, which guard against short circuit and injury.

Carburetion—A duplex carburetor, each tube supplying one set of three cylinders, is used. This assures a more satisfactory charge than a single carburetor equipment, due to the separate manifolds which prevent starving and eddying, and the better vaporizing properties of two small carburetors over one large one. In addition, hot water jackets are provided on the manifolds to assist in vaporizing the gasoline.

Lubrication—Lubrication is secured by pressure feed through crankshaft, propeller shafts and cam shafts, which insures a continual film of clean oil on all bearings. A separate return pump, with double intake, prevents accumulation of oil in either end of pan, and the consequent flooding of cylinders, when the machine is climbing or gliding. Pressure adjustment permits of individual adequacy of oil feed on each engine and change for wear and varying conditions of service.

Bolts and Nuts—All bolts and nuts are made from special steel, of specified hardness according to scleroscope test. Every nut is either cotter pinned, lock washered, or safety wired in series.

Formula for Approximating Propeller Diameter

By Edward P. Warner

Before we can proceed to the design of a propeller by the usual methods, it is necessary to estimate the diameter that will be required, so that we may be able to choose proper proportions for the various sections. Unless we can find some formula which will obviate the element of guesswork, the first estimate is likely to be far astray, the diameter being either underestimated or overestimated, resulting in an absurdly wide or an absurdly narrow blade to absorb the required power. A logarithmic diagram can be used if it is at hand, but a simpler method is desirable, and it is with this end in view that I have sought for a formula which could be applied with a minimum of effort and knowledge, yet which would eliminate the danger of false starts in the design computations, and which would also be useful during the preliminary layout of the airplane in determining the chassis height necessary for a given ground clearance under the propeller.

Drzewiecki, originator of the propeller theory which usually bears his name, and which is almost universally used in one form or another, has devised a so-called "equation of compatibility" which can be used for determining diameter, but it has the disadvantage that the constants involved are not non-dimensional, so that the formula is not equally applicable to propellers of all sizes and types. Furthermore, it was published so long ago that the data on which it was based are quite out of date, propeller blade forms and sections having changed greatly in the meantime.

In deriving our formula, we shall assume that the efficiency is the same for all propellers, and that the horsepower absorbed is therefore proportional to the product of the thrust and the speed of flight. In actual practise, it is found that this assumption involves only comparatively small errors. If we assume the validity of the Drzewiecki theory of design, we have, for the thrust on an element:

$$T = K_y \times b \times dr \times V_r^2 \times \cos(A + G)$$

where K_y is the lift coefficient of the section employed, b the blade width at the element in question, dr the length of the element, V_r the resultant velocity of the element through the air, A the angle which the path of the element makes with a plane perpendicular to the propeller axis, and G the angle which the line of action of the resultant force on the element makes with the perpendicular to the path of the element. K_y depends on the type of section chosen and the angle of incidence at which it is set.

An arbitrary constant will have to be introduced in our formula to allow for the variations in the value of K_y. The value of b depends on the maximum blade width and on the form of the blade, being directly proportional to the maximum blade width so long as the blade form remains unchanged. A second arbitrary constant will then have to be introduced to allow for variations in the shape of the blade; dr is directly proportional to the diameter, if we assume all the propellers considered to be divided into the same number of elements. V_r is very nearly proportional to the product of the diameter by the number of revolutions per minute. Cos $(A + G)$ varies so little as between different propellers that it may safely be considered constant.

We then have the thrust on an element very nearly proportional to $BD^3N^2K_1K_2$, where B is the maximum blade width, D the propeller diameter, N the r.p.m., and K_1 and K_2 arbitrary constants. Since all propellers are assumed to be broken up into the same number of elements, the thrust on an entire blade is proportional to this same quantity. The thrust given by the whole propeller is equal to the thrust on one blade multiplied by the number of blades, and we finally arrive at the conclusion that the power absorbed varies approximately as $BD^3N^2K_1K_2nV$, where n is the number of blades and V is the speed of flight. In equation form, $P = CBD^3N^2K_1K_2nV$, in which C being a constant, the value of which can be determined by substituting in the formula the characteristics of propellers which have proved satisfactory in practise.

C has been determined for a considerable number of propellers, and the mean value has been taken, giving the following formula as a result.

$$P = \frac{K_1K_2BD^3N^2nV}{10{,}000{,}000{,}000}$$

D = propeller diameter (ft.)
B = maximum developed blade width (in.)
N = revolutions per minute (of propeller)
n = number of blades
V = speed of flight (m.p.h.)
K_1 = coefficient of blade form (0.75 — 1.00)
K_2 = coefficient of section and angle (0.75 — 1.00)

K_1 has its maximum value for propellers of constant blade width or those which are widest very near to the tip of the blade, its minimum for those which are widest near the root of the blade. For propellers of the usual blade form, with a rounded tip and the maximum width about ¾ of the way out, $K_1 = .85 — .9$.

K_2 has its maximum value for propellers with a cambered blade at a large angle of incidence (about 6 deg.), its minimum for sections of low-lift type set at a small angle (about 2 deg.). K_2, also, will lie between .85 and .9 for most propellers, so that it is not possible to make a very large error in the estimation of these constants. If we always take the value on one as .9 and the other as .85 we cannot go very far astray.

As an illustrative example, we may find the diameter for a two-bladed propeller for the Liberty engine, developing 400 hp. at 1,700 r.p.m., mounted on an airplane flying 125 m.p.h. We shall assume the maximum blade width to be 10 in.

$$400 = \frac{.85 \times .9 \times 10 \times D^3 \times (1{,}700)^2 \times 2 \times 125}{10{,}000{,}000{,}000} = .553$$

$$D = \sqrt[3]{\frac{400}{.553}} = 9.0 \text{ ft.}$$

Winds and the Trans-Atlantic Flight

By Frank T. Tucker

Past performances of Zeppelins, Italian airships, giant Handley-Page airplanes and large flying boats bear out the prediction that there are machines in existence today that are perfectly capable of making a trans-Atlantic flight, providing favorable wind and weather conditions are encountered.

The main question that seems to be worrying pilots who are contemplating the flight seems to be the wind and weather conditions through which their course must be mapped. If an airship is used for the first successful flight, as now seems highly probable, the wind factor is of the greatest importance, and it would be a controlling element in the navigation of a heavier-than-air machine from this country to Europe.

What wind conditions prevail over the North Atlantic? At what height should the flight be attempted to get the aid of favorable winds, and in what course would the winds be found most favorable for an eastward or westward journey?

These are the questions now confronting the pilot who is planning a trans-Atlantic flight. The data upon which he must base his navigation calculations are somewhat meager, but such data have been gathered and have been waiting for years to be tested out.

The atmosphere of the North Atlantic was charted several years ago in anticipation of the demands of the pilots of today who are now ready to attempt the flight. Messrs. Teisserenc de Bort and Rotch conducted four expeditions in 1905-7 on their steam yacht Otaria, for the purpose of exploring the atmospheric conditions in the intertropical regions of the Atlantic by means of balloons sent up from the deck of the vessel. The Otaria observations were made both north and south of the equator, but only the results of those made in the northern hemisphere were published. The observations made by these gentlemen, together with similar observations made of the atmosphere over the United States, were published in the "Travaux Scientifiques de l'Observatoire de Trappes, avec la Collaboration de l'Observatoire de Blue Hill," in 1909, and offer valuable data on the frequency and velocity of winds over the North Atlantic.

Balloons were released from the deck of the Otaria at frequent intervals. The speed of the balloon's ascent was known, and its angular position observed by means of a sextant from minute to minute. In this way the velocity and direction of the wind up to heights as great as 30,000 ft. was determined. The observations during the summer months were made between 10 deg. and 30 deg. north latitude, and 16 deg. and 40 deg. west longitude. In the winter they were confined to 5 deg. and 25 deg. north latitude. A total of 715 observations were made in sixty-seven balloon ascensions, and the data obtained shows the possibility, and even the probability, of steady and favorable winds for a flight in either direction across the Atlantic.

Seventy-four per cent of the winds at sea level were found to be from the northeast. These northeast winds were found to exist more frequently than others up to 10,000 ft., although at 1650 ft. their frequency began to decrease. East and southwest winds became the most common at 20,000 ft., and at 30,000 ft. southwest winds were by far the strongest and most frequent. The observations showed that at least three-quarters of the time a steady northeast trade wind was blowing near the surface of the sea. While this would be a distinct aid to a westward flight, pilots attempting the eastward journey must seek a course above or outside the range of these winds.

The velocity of the northeast winds at sea level was found to be from 10 to 15 m.p.h., increasing to 25 m.p.h. at 20,000 ft. At this height, however, westerly winds were the strongest; and while the frequency of the winds from the northeast was the greatest, the velocity of those from the opposite direction should compensate for this disadvantage on an eastward flight. This change is shown by the fact that at the great height of 30,000 ft. the average velocity of winds from a general easterly direction was 19 m.p.h., while that of the westerly winds was 33 m.p.h.

The height at which the southwest counter trade winds begin was found to vary greatly, but they generally set in at about two miles above sea level.

Other observations, conducted by the Manchester observatory near the west coast of England, and the Blue Hill observatory in the United States, corrected by reference to the Pilot Chart of the North Atlantic ocean, show the probability of favorable westerlies at a height of about 3300 ft. These data show that winds of a velocity ranging from 25 to 28 m.p.h. blow from west-northwest and southwest more than half the time at this altitude. The Blue Hill data show that the west and southwest winds blow as far as 30 deg. west longitude. The Manchester observations show that winds of a velocity of 28 m.p.h. blow at least half the time from west and northwest at 30 deg. west longitude at the same height of 3300 ft.

Using these data, a pilot should be able to chart a very favorable course from a point such as Boston at 42 deg. north and 71 deg. west in an east-northeast direction to latitude 53 deg. north, longitude 30 deg. west, the extreme easterly point of the Blue Hill observations. The altitude would be 3300 ft. and the flight would have to take place in the summer to take advantage of the wind conditions found in the data.

From 30 deg. west the Manchester observations should serve as a guide to the pilot. At this point favorable winds from the northwest are prevalent, which would encourage a change in the course to one almost due east with London, at 50 deg. north and 0 deg. longitude, as an objective. Observations show that fair weather and few storms prevail over this route in summer, and it is high enough to be above the fog. The temperature at this altitude varies slightly between 50 deg. and 60 deg. F., which would be a valuable factor if a lighter-than-air craft were used.

The flight westward from Europe to the United States would be much easier to chart from the standpoint of wind and weather conditions, as the surface trade winds would furnish a very favorable channel for such a flight. June would be the best time for a trip over this route, as storms are rare along the course suggested by the Otaria data, combined with that of the United States Hydrographic Office. This course, starting from Lisbon, at 38 deg. north and 9 deg. west, 2200 miles southwest to latitude 18 deg. north, longitude 40 deg. west, would take advantage of the northeast winds that prevail along such a route. The flight could be made at a very low altitude, as the northeast winds diminish in frequency with height and increase very slightly in velocity. At 40 deg. west, the data suggest that the course be changed to employ the more easterly wind along a course of 1400 miles to the Lesser Antilles as the destination at latitude 15 deg. north and longitude 61 deg. west.

As these data have never been proved by an actual flight, it remains for the pioneers in trans-Atlantic flying to test them out and to establish new data based upon actual experience that will make the trans-Atlantic flight not merely a feat, but a common, safe and speedy means of transportation and communication between the continents.

Aeronautical Patents

ISSUED DECEMBER 31, 1918

1,289,131—To Warren S. Eaton, Plainfield, N. J. Hydroaeroplane.
1,289,402—To Jacob M. Cripe, Des Moines, Iowa. Airship.
1,290,026—To Charlie B. Smith, Kokomo, Ind. Aeroplane.
1,289,206—To George Lanzius, New York, N. Y., assignor to Lanzius Aircraft Co. Aeroplane.
1,289,276—To Isaac Schafran, Newark, N. J., assignor of one-half to Jacob Thaler, New York, N. Y. Aircraft.
1,289,343—To Albert Wolff, Jr., San Francisco, Cal. Aeroplane-speed accelerator.
1,289,683—To Glenn H. Curtiss, Buffalo, N. Y., assignor to Curtiss Aeroplane & Motor Corp., Buffalo, N. Y. Flying boat.
1,289,967—To Frank Torres, El Paso, Tex. Flying machine.
1,289,163—To Marcellus M. Halton, Ripley, Tenn. Aircraft.
1,289,579—To Cal Trotter, Colorado Springs, Colo. Parachute.
1,289,118—To George W. Cline, Albany, Ore. Stabilizer for flying machines.
1,290,025—To Howard M. Rinehart, Dayton, Ohio, assignor to The Dayton Metal Products Co., Dayton, Ohio. Aeroplane control.
1,290,005—To Paul G. Zimmerman, Buffalo, N. Y., assignor to Curtiss Aeroplane & Motor Corp. Fuselage cover.
1,289,703—To Chester F. Dutton, Hancock, N. H. Gas-escape valve for balloons.
1,290,004—To Paul G. Zimmerman, Buffalo, N. Y., assignor to Curtiss Aeroplane & Motor Corp. Aeroplane fitting.

News of the Fortnight

Annual S. A. E. Meeting

The annual meeting of the Society of Automotive Engineers, held on Feb. 4-6, 1919, at the headquarters of the society, in New York, was a representative gathering of the aeronautical world, both owing to the several important papers dealing with aeronautics that were presented and the large number of aircraft engineers and officers of the Army and Navy Air Services who attended the meeting.

Among the aeronautical papers presented were: Airplane and Seaplane Engineering, by Comdr. H. C. Richardson, U. S. N.; Problems of the Naval Aircraft Factory During the War, by Comdr. F. G. Coburn, U. S. N.; Experimental Aeronautical Engineering, by Alexander Klemin; Making the Airplane a Utility, by Grover C. Loening; The Liberty Aircraft Engine, by J. G. Vincent; Fixed Radial Cylinder Engines, by John W. Smith.

The officers elected by the S. A. E. for the current year are: Charles M. Manly, president; B. B. Bachman, first vice-president; B. H. Belden, second vice-president, representing motor car engineering; Elmer A. Sperry, second vice-president, representing aircraft engineering; T. B. Funk, second vice-president, representing tractor engineering; John J. Amory, second vice-president, representing marine motor engineering; L. S. Keilholtz, second vice-president, representing stationary and internal combustion engineering. Members of the Council: E. A. de Waters, David Ferguson, Edward A. Johnston, Charles S. Crawford, J. B. Whitbeck, David Beecroft. Treasurer, Charles B. Whittlesey. Secretary and general manager, Coker F. Clarkson.

Inter-Allied Air Conference

The inter-allied air commission will meet in Paris shortly to settle the big problems connected with the aerial traffic of the world. Technical experts of the various powers now are engaged on plans to be submitted to the commission. The British scheme, according to the Paris edition of the London *Daily Mail*, is ready.

One of the chief difficulties to be overome is the drawing up of a set of rules for aerial passage applicable to all nations, in view of the complicated geographical conditions. Ordinary rules for flying, such as speed, height, navigation, lights and so forth, are easily adjustable, but the political and commercial aspects are bound to involve controversial points.

Loening Monoplane Makes Record

Major R. W. Schroeder, Air Service, the holder of the American altitude record, established a new record for monoplane altitude on Jan. 18, at Dayton, Ohio.

According to a telegram received from the Chief of the Technical Section, Division of Military Aeronautics, McCook Field, Dayton, Ohio, the Loening monoplane climbed to 19,500 ft. with three passengers totaling 470 lb. The pilot was Major R. W. Schroeder, the observer, Lieut. George V. Elsy, and mechanician, K. A. Craig. The previous altitude record for a monoplane with three passengers is understood to be about 16,000 feet.

A report from Mr. Loening gives the time as thirty-nine minutes, which would average approximately 500 ft. per minute.

British Air Raid Casualties

In raids on the United Kingdom by the Germans during the war 5611 persons were killed or injured, of whom 4750 were civilians. An official summary of the casualties caused by German airships, airplanes and bombardments from the sea shows these casualties among civilians:

Killed—554 civilian men, 411 women, 295 children.

Injured—1508 civilian men, 1210 women, 772 children.

Three hundred and ten soldiers and sailors were killed and 551 were injured.

There were fifty-one raids by airships, causing the deaths of 498 civilians and the injury of 1236 and the killing of 58 soldiers and sailors and the injuring of 121.

In fifty-nine airplane raids 619 civilians were killed and 1650 were injured. In these raids 238 soldiers and sailors were killed and 400 injured.

A. T. Murray Heads Bosch Corp.

A. T. Murray, the acting head of the Bethlehem Motors Corp., has been appointed president of the American Bosch Magneto Corp. At the time of the taking over of the Bosch holdings in the United States by the Alien Property Custodian, Mr. Murray was appointed managing director of these interests and his handling of the extremely difficult situation which the operation of the Bosch activities involved proved him to be particularly fitted for this post.

The American Bosch Magneto Corp. has taken over the entire holdings and organization of the Bosch Magneto Co., including the great Bosch works at Springfield, Mass., which comprises 250,000 sq. ft. in the building alone and employs 1,500 operatives. The officers of the corporation are, beside Mr. Murray, George A. MacDonald, vice-president and treasurer; A. H. D. Altree, vice-president; Leon W. Rosenthal, vice-president; J. A. MacMartin, assistant treasurer and secretary. The board of governors consists of A. T. Murray, Martin E. Kern, George A. MacDonald, Henry N. Sweet, C. H. Dwinnell, H. C. Dodge, Duncan C. Holmes, Phillip L. Spalding and H. B. Benedict.

Paris-Berlin Air Line

Linking of the American peace commission in Paris with Berlin by airline is planned in connection with the visit to Germany of an American mission which will send back reliable information as to conditions in that country for the guidance of President Wilson at the Peace Congress.

It is the intention to have American army aviators bring back by airplane data collected by the mission. This will save much time which now is lost because of the broken down train service and the delays between Paris and Berlin and unreliable wire communication.

The air courier service will be operated in relays, like the old time pony express of the plains. The first flight will be to headquarters of the Third Army at Coblenz, thence following the River Main to Beyreuth and across the Fichtel Mountains to Prague. Changing again at Prague the airplanes will fly direct to Berlin. Aerodromes and gasoline stations are now being established at Prague.

It is not believed to be possible to start an air courier daily, because the weather not always will permit this, but it is believed that an average of four days a week can be reached. A number of the foremost American army aviators have applied for assignments in this service.

McCook Field for Civil Testing

To promote peace-time development of the aircraft, the War Department has placed McCook Field, Dayton, Ohio, at the disposal of private enterprise for testing experimental types of machines. Regulations made public Jan. 27 provide that all unofficial tests shall be at the owners' risk and expense, and after examination of the machine by Army technical experts to determine its safety for trial in the air.

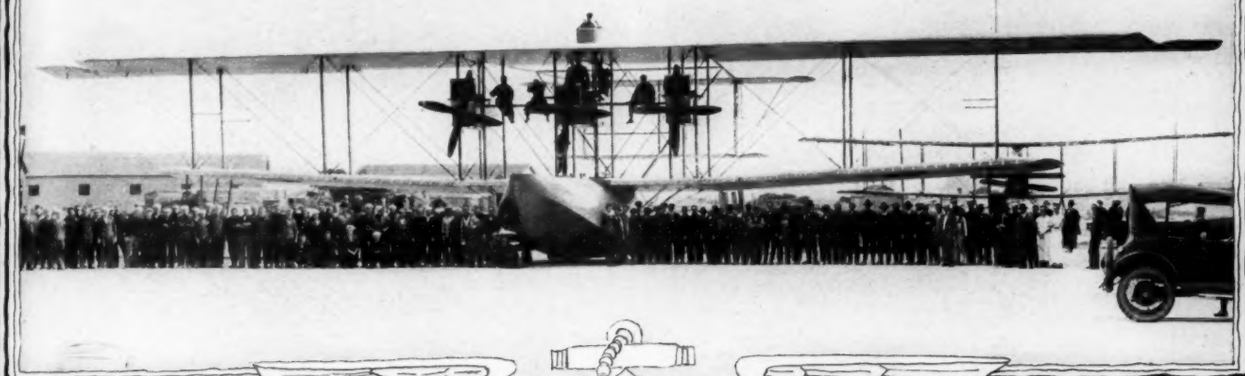
Official tests also will be conducted at McCook Field by Army pilots experienced in experimental work. For such trials owners must submit two machines, one for a destruction test and one for performance. The Government will defray the expense.

Lectures on Aero Engineering

A series of evening lectures are being delivered at the Polytechnic Institute of Brooklyn, N. Y., by Alexander Klemin, consulting aeronautical engineer and technical editor of AVIATION AND AERONAUTICAL ENGINEERING, which deal with the theory of aeronautical engineering and will provide a basis for subsequent work on the practice of aeronautical engineering.

Cato with Marlin-Rockwell

J. L. Cato, experimental engineer in charge of all development work of the L. W. F. Engineering Co., has resigned from that firm to develop for the Marlin-Rockwell Corporation a new all-ball bearing aeronautical engine, which will power a new sporting type of monoplane of his own design.



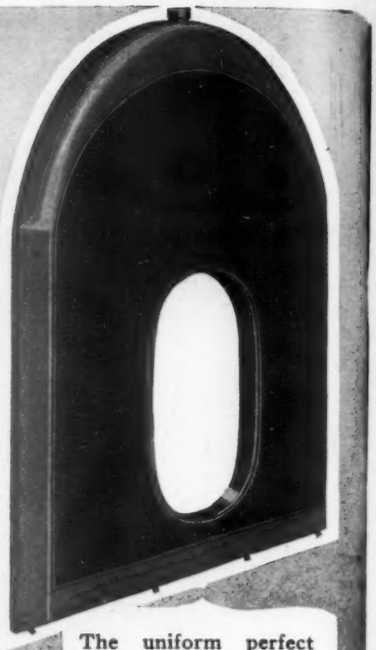
A Great Naval Achievement

The remarkable flying boat shown in the photograph above is one of the epoch making achievements of naval aviation. It is the largest flying boat in the world—a craft capable of flying with eleven (11) tons. This same naval plane recently flew with fifty Navy men and pilot aboard.

Developed and built at The Curtiss Engineering Corporation, Garden City, by Naval Constructors working in collaboration with Glenn H. Curtiss and his engineers, it stands today as a proved product of unquestioned superiority, entirely American in its conception, evolution, manufacture and performance.

CURTISS AEROPLANE & MOTOR CORPORATION
52 Vanderbilt Avenue New York City, New York
Factories: Buffalo and Hammondsport
Curtiss Engineering Corporation, Garden City, L. I., N. Y.

Radiation not just Radiators



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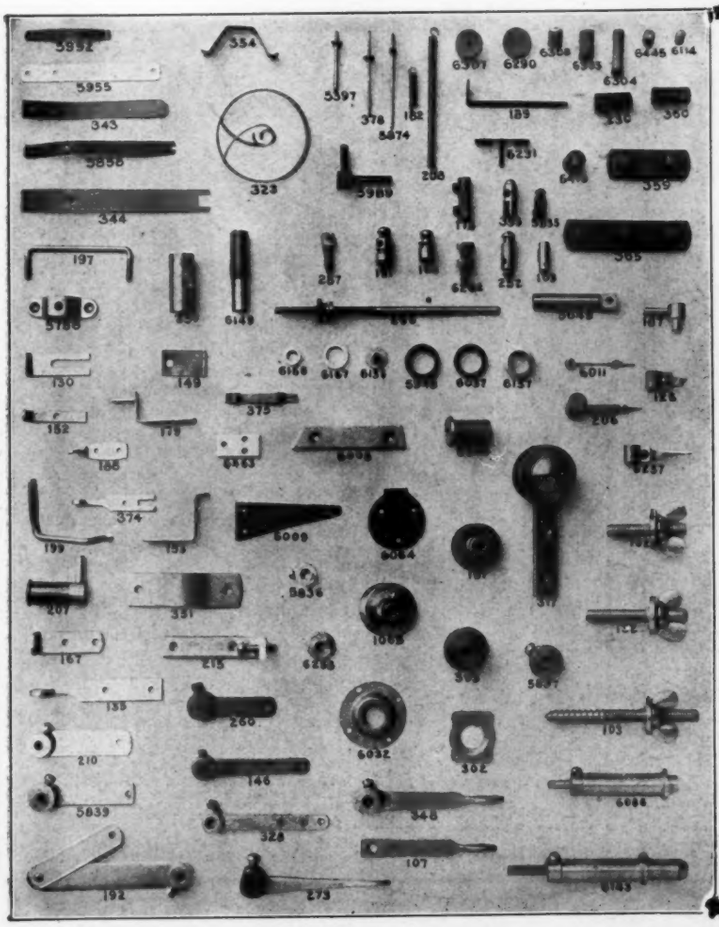

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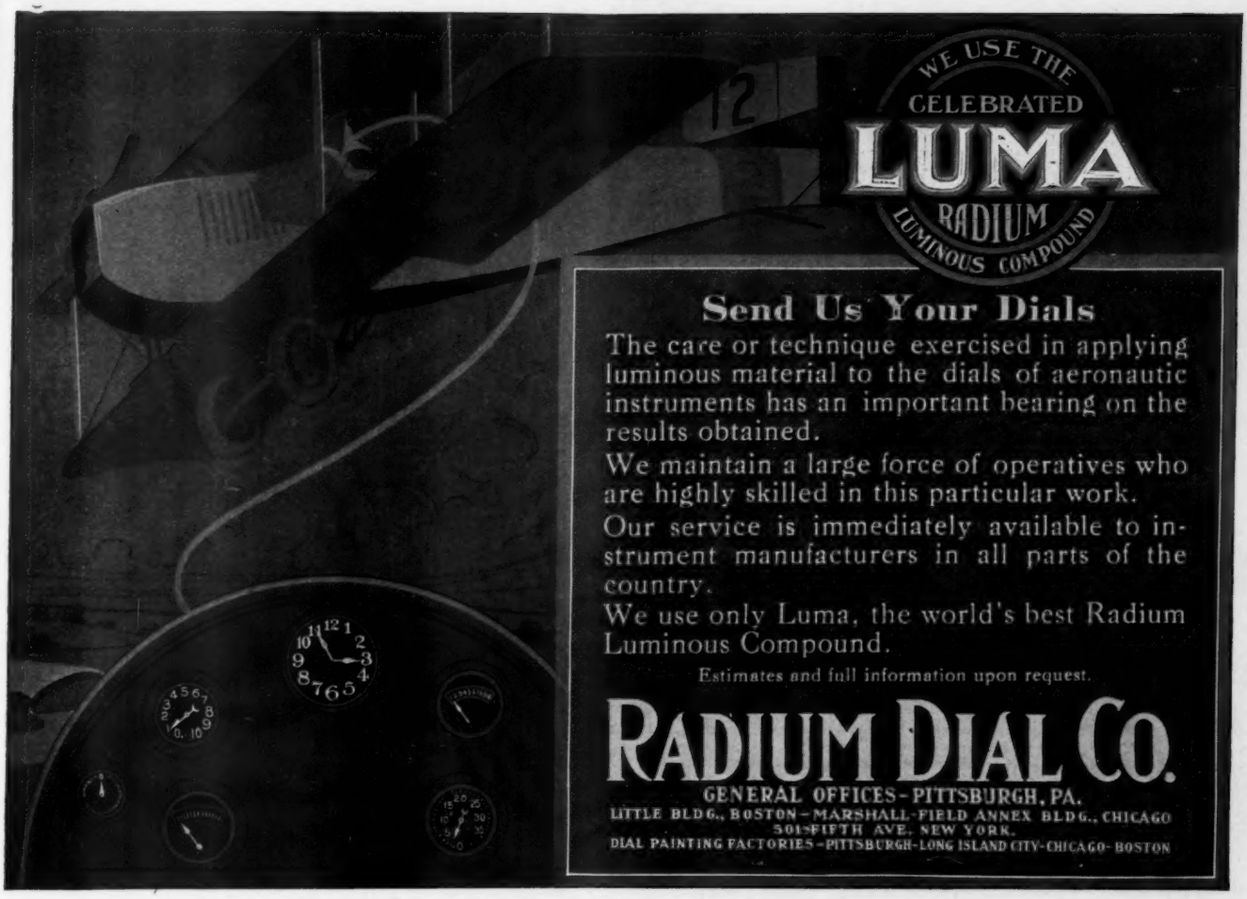

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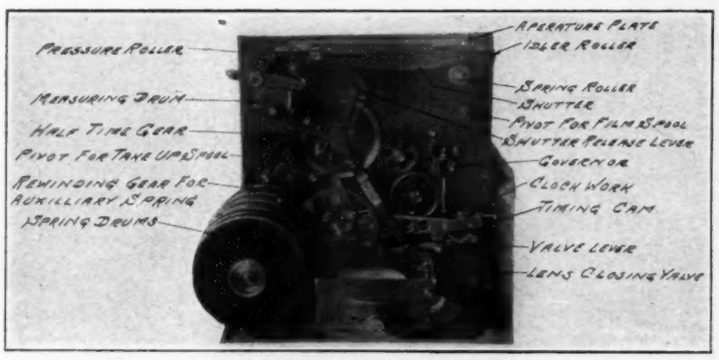

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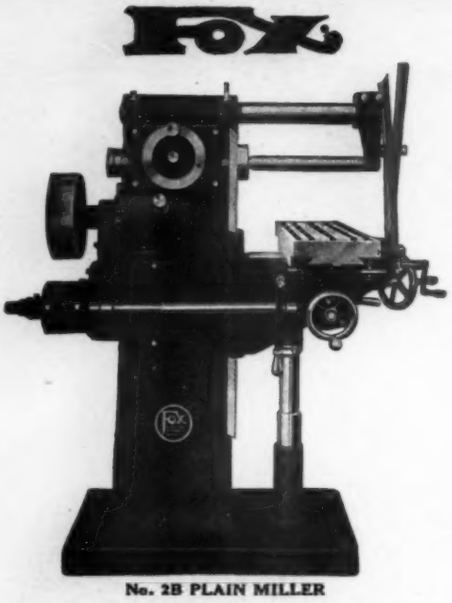

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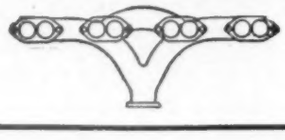

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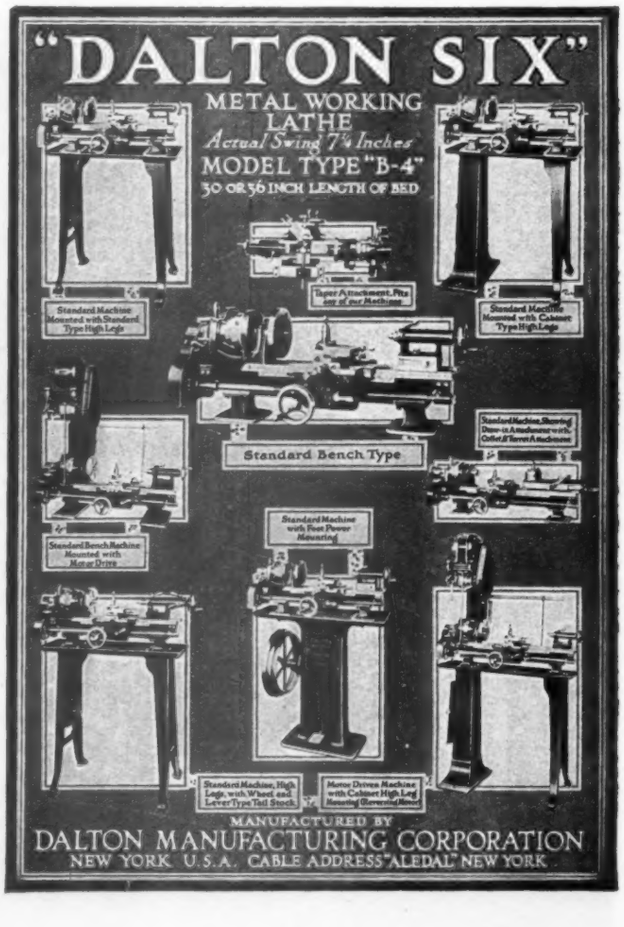

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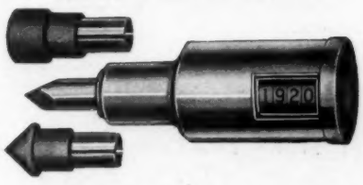

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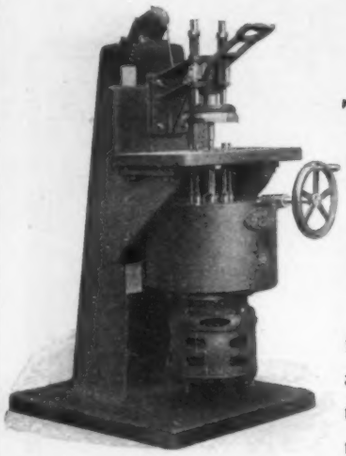

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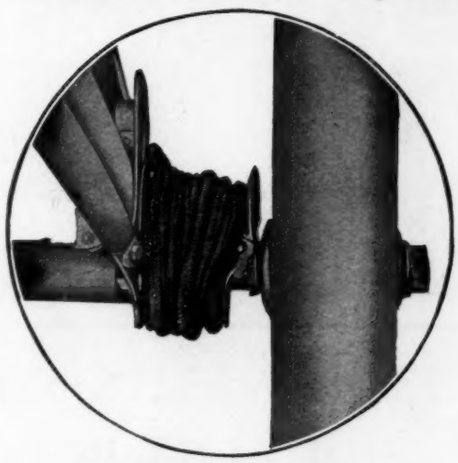

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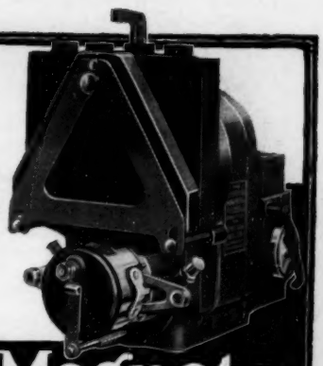

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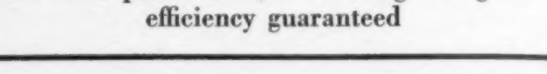

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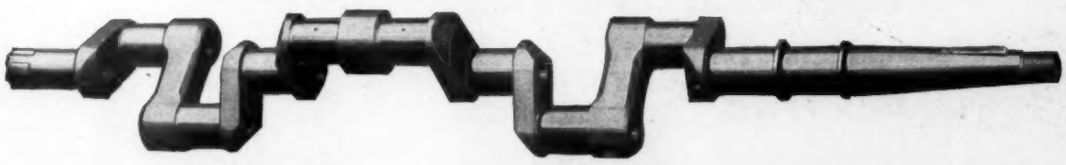

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